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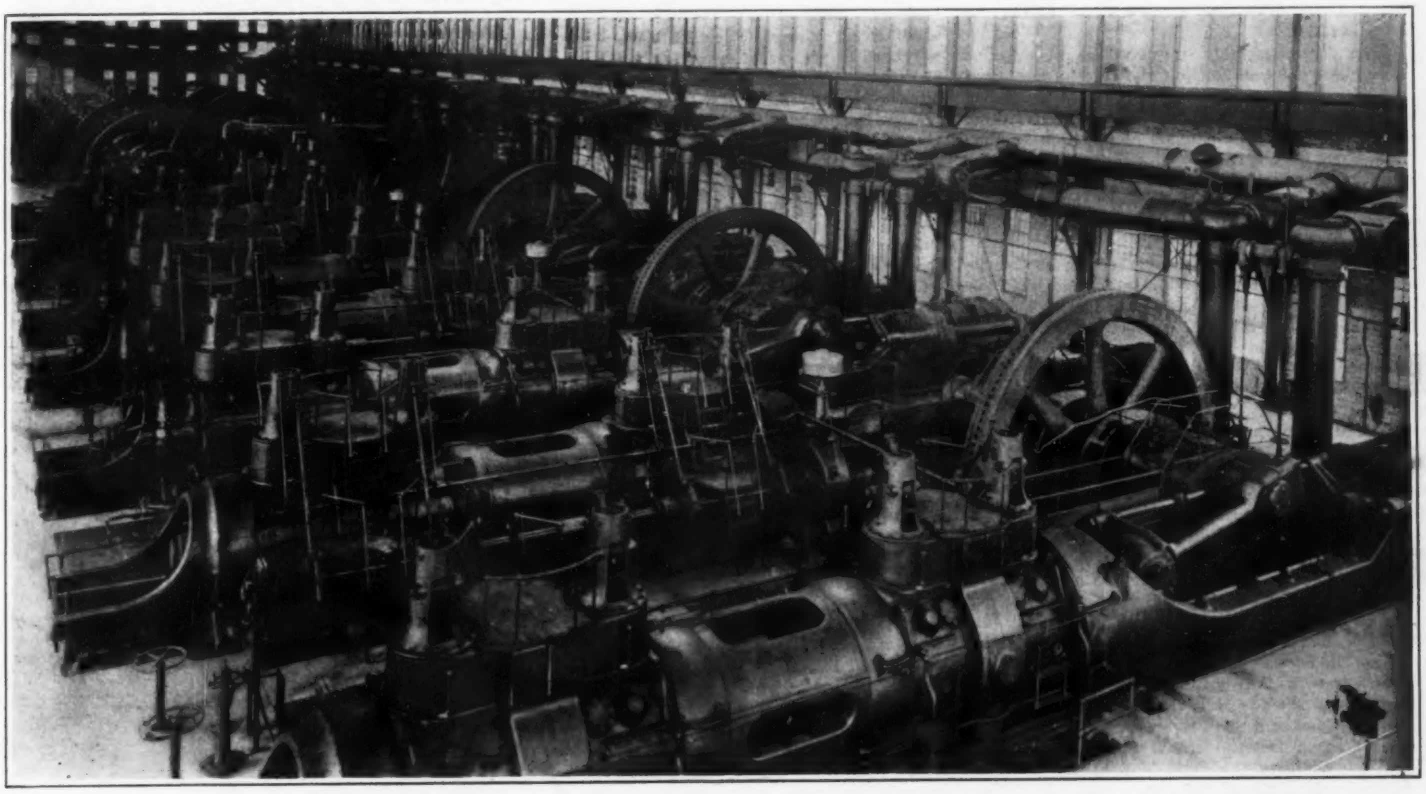
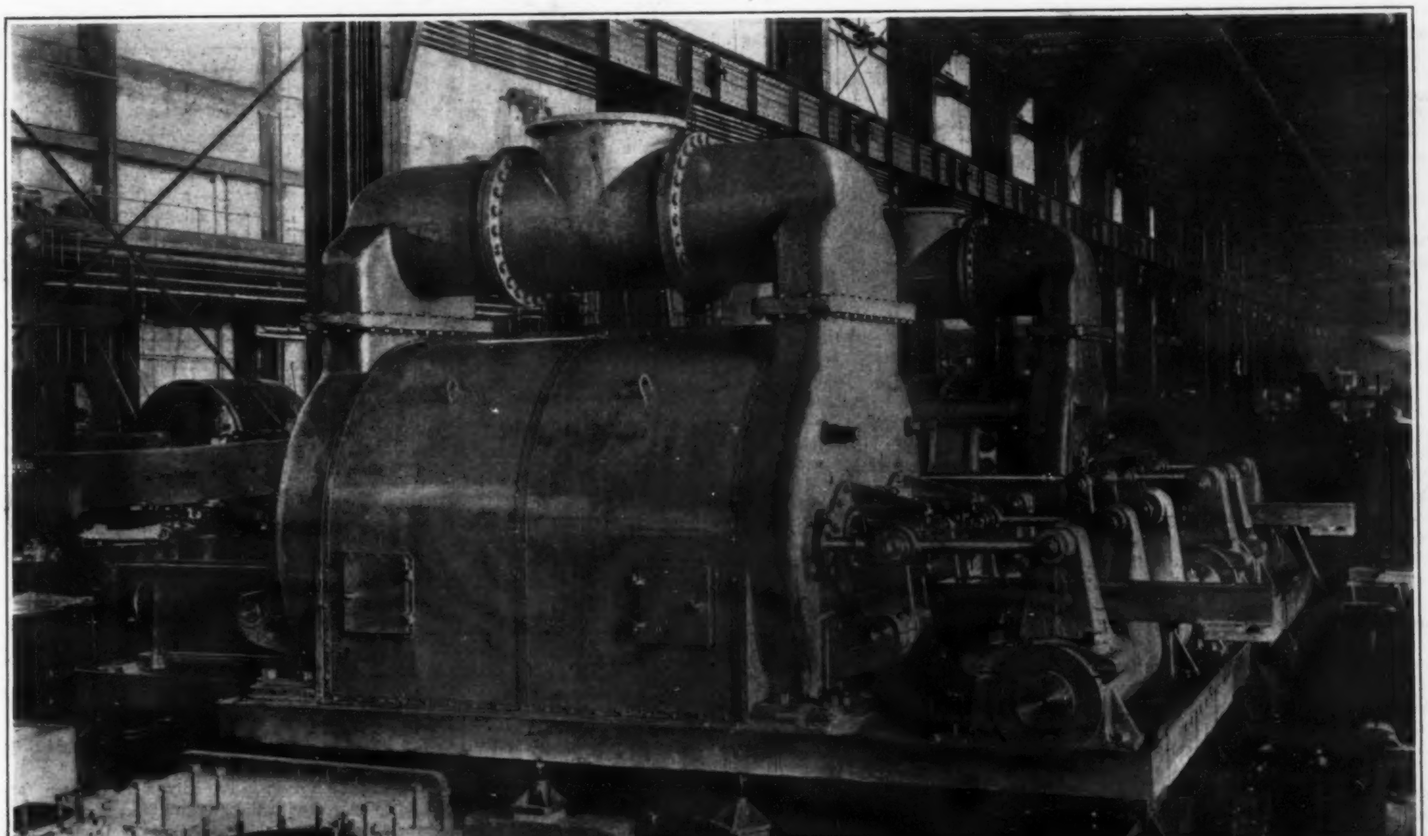


LOOKING NORTH THROUGH ONE OF THE INDIANA STEEL COMPANY'S BLOWING ENGINE HOUSES CONTAINING EIGHT ALLIS-CHALMERS GAS ENGINE BLOWERS



THE SLICK "BLOWING TUB"

GIANT GAS ENGINES AND BLOWING TUBS—[SEE PAGE 329]

The Nature of Invention*

How it is Governed by Evolution

By J. Löwy

I.

The problem of fathoming the creative activity of the human mind, of investigating the causes and the laws which determine the action of this mysterious agency, has in all times engaged the attention of the thinkers of the civilized world. In spite of all efforts and astute analysis, however, no satisfactory conclusion has ever been reached. The reason for this is twofold.

In the first place, the case has been regarded as standing more or less by itself and disconnected from other natural phenomena; a kind of sacred fear seems to be felt of attacking it from a purely objective point of view like any other subject of scientific inquiry. The analysis of creative mental activity was reserved to metaphysics, and consequently failed to yield a clear result, capable of rigid proof, and fitting in without straining with the general plan of our knowledge of nature.

The second cause of the failure of the earlier attempts to solve the problem lay in the fact that the methods and results of scientific investigation had not yet reached that state of perfection which they possess at the present time.

We are to-day fully justified in assuming that all the phenomena of which we can become cognizant, whether they belong to the domain of matter or to the world of ideas, are subject to the universal process of evolution and its laws. If we take a survey of the world in the light of the laws of evolution, all the boundaries which seem to divide the several domains of nature seem to be suddenly erased. There is no longer any deep cleft dividing the inorganic from the organic, the living from the non living, or plants from animals. Not only the concrete objects of nature are seen to be subject to the laws of evolution, but also the realm of thought. Thus the great epistemologist, E. Mach, has said: "Ideas are not individual organisms. They are, however, manifestations of organic life. If Darwin saw truly, they, too, must display a succession of transformations and an evolution." The products of our mind represent special, non-material branches proceeding from a material trunk, the brain, and are therefore subject to the same laws as the material members in the chain of evolution.

II.

It is proposed, in the lines which follow, to consider the phenomenon of "invention" from the point of view of epistemology. We shall see that this activity of the human mind, mysterious and unfathomable as it appears, proceeds strictly according to rule and obeys the laws of evolution.

The history of civilization shows that man originally was dependent for the performance of his various activities upon natural organs, such as the hand, the teeth, etc. At a later stage man learned to employ articles which he picked up in nature, such as branches of trees, flints, bones, turning them into rude implements. Still later, primitive man learned to modify articles accidentally found, so as to better adapt them to his purposes. In doing this, he, as a rule, copied some existing organic example. Thus, for instance, he made the ax in the image of the human arm and fist, and the saw may be said to have been patterned after the human jaw, with its teeth. The process of adapting the implements to their work went on vigorously, until finally these artificial aids excelled in usefulness for their particular purpose the organic patterns after which they were fashioned.

The process of adaptation, which we term "invention," takes its course under the guidance of the human will, which itself is governed by law. The basis from which the operation necessarily starts is the stock of facts known to the inventor, who, as a rule, proceeds in such logical manner that in most cases we have presented to us the appearance of a methodical process of invention, seemingly quite independent of accident. The law and order which holds its sway over invention is not clearly realized by the inventor; a large part, perhaps the most essential step, in the mental process leading to invention, takes place subconsciously; it appears as if some invisible power were guiding the process of thought.

That invention and technical developments follow a prescribed course is proved by many technical products, which were not consciously evolved as copies from nature, but which were subsequently found, through the discoveries of physiology, to be analagous in structure to human organs. Thus, for example, the piano represents a faithful copy of the ear, though it was built without any knowledge whatever of the structure of that organ, and similarly the camera is a close copy of the human eye. Human creative activity, therefore, begins with the unconscious copying of nature, and unconsciously continues this copying process.

Similar requirements produce in the technical arts the same type of devices as they do in the organic world. The process of invention is a manifestation of natural forces, just like all other processes of evolution—the inventor is merely a tool blindly following the law of nature; it is not the inventor who invents, but, as it were, nature which invents in him, and which through him and his technical achievements, furthers the general process of evolution.

Animal technique, also, is a proof of the law which guides all technical products. Certain structures built by animals are so well calculated for the purposes for which they are intended, and are in such excellent accord with the laws of mathematics and physics, that even man could not, with the same means, produce anything more perfect. We need only call to mind the ant hills of the termites, and the hive of the bee. The most important tool which human engineering commands, over and above those at the disposal of animals, is the weapon of mathematics, by the aid of which he shortens the process of evolution. The laws formulated in mathematical guise are, however, nothing more than the epitome of experiences previously gained by man. Just as animals inherit the accumulated technical experience of their progenitors in their instincts, so man hands down his acquisitions in the form of the natural laws and mathematical formulæ discovered by him.

III.

We are provided by nature with organs of special sense which respond to a limited number of forms of energy, such as for instance, light and sound. For a number of other forms of energy, we possess instruments, the products of technical industry, which enable us to detect the presence of these forms of energy. Thus, for example, the coherer serves to detect electric waves, a bismuth spiral discloses magnetic radiation, and the barium platinocyanide screen renders us conscious of the X-rays. These instruments accordingly fulfill the functions of natural organs. They are, like all other technical products, nothing more than products of adaptation to nature, auxiliaries in our struggle for existence. Where organic evolution ceases, technical evolution sets in as its continuation. Instead of improving the eye, nature created the telescope and the microscope, instead of strengthening our muscular powers, it created working engines. Instead of adding new organs to those which we possess, it created for us artificial organs.

Technical and organic evolution merge into each other, both serve the same purpose, both follow the same laws. The question then arises: "Why and by what circumstances is organic evolution separated from technical evolution?"

We have seen that technical creations represent products of adaptation of our being to nature, just as is the case with our organs. The mode of origin of these products of adaptation we may, according to modern scientific views, picture to ourselves in this way, that the stimuli exerted by external forces upon the existing organism have directly caused the development of such organs as are suited for the perception of the stimuli and the fulfillment of the requirements created by the stimulus. The products of adaptation thus formed serve in the first place the purpose of removing the cause of the stimulus, which is usually felt as an irritation, and often as a positively painful and dangerous condition. In the same measure as the process of adaptation advances, the stimulating action is diminished; when the body is perfectly adapted to its environment, the stimulus which initiated the process has ceased to act altogether. In this way, the stimulating action of light has produced the eye, the stimulus of a toxine in the body produces the anti-toxine; and similarly water, under the influence of high temperature, is converted into steam, which accordingly presents itself as a modified form of water adapted to those temperatures.

Every organism is subjected to a variety of forces, and the organism is thereby compelled to adapt itself to stimuli. So long as adaptation was possibly only within the limits of organic processes, this adaptation went on excessively slowly; when, however, the organ of thought, the brain, had reached a certain stage of evolution, these stimuli no longer acted merely upon the portion of the organism directly concerned, but also upon the thinking organ. As the result of this, any inability on the part of the body to react to the stimulus is unpleasantly felt by the brain, which therefore seeks to discover some rapid method of adaptation, and overtakes and therefore renders unnecessary organic adaptation. In this way the technical arts came into being as the continuation of organic evolution.

IV.

On the basis of conclusions reached so far, we shall now have no difficulty in satisfactorily answering a number of questions which arise in connection with the subject of invention. If, in this process, we divest the inventor of some of the glory in which he is ordinarily enveloped, this will be in some measure compensated for by the fact that we shall gain a better understanding of his activity. The honor which we shall then pay him will, it is true, be far removed from a feeling of sacred fear or adoration, but will nevertheless be a perfect and sufficient substitute, inasmuch as we shall learn to appreciate the pains, the labors, and the disappointments of the inventor, and shall thus be placed in more immediate human relation to him.

The first fact which strikes us is that no invention, however epoch-making, was purely the product of the head of him to whose name the glory is attached. Every invention represents a temporary end point in a long series of technical perfecting steps, which are all connected together like the links of a chain. In many cases, the merit of the last inventor, upon whom falls the reward and the applause of his fellows and of posterity, is considerably smaller than that of many of his predecessors. He, a favorite of fortune, whose good luck it was to appear upon the scene at a later date, has thrown into his lap, often through some quite secondary performance on his part, the mature fruit, the natural outgrowth of the ground prepared by earlier investigators.

The fact that the development of every invention follows a definite law is also the explanation of the frequently observed fact, that the same invention is made simultaneously by different inventors, working independently. Working on the same basis of previously accumulated knowledge, and placed under the same pressure of similar necessities, they must necessarily reach the same results, representing the last product of evolution. The accusation of plagiarism must therefore be made with great circumspection in matters relating to technical industries.

We can also understand, from our present point of view, that a man can become a genius of invention only by assiduous labor and study of all that is already known in the field in question. Every invention recapitulates in the head of its creator all the principal stages of its gradual evolution in the past history of the race. The layman, as a rule, merely rediscovers something which has long been surpassed in the art. For his invention represents the last step in order in the evolution of *his* knowledge, which is not up to date.

To what extent the creative activity of the inventive mind depends on the stimulus of his environment is best recognized from two facts. The first of these is a well-known observation, familiar in the patent offices of all countries. Generally speaking, in every domain of industry there is a steady production of inventors which remains approximately constant at all times. The moment, however, that through any circumstances the attention and the thoughts of the world are directed to any particular problem and its solution, the number of inventions relating to this particular field goes up by leaps and bounds.

The second fact which is to be mentioned as a sign of this stimulating influence of the environment is the observation that technical men who have proved themselves eminent inventors in their professional practice become almost entirely sterile as soon as they leave the battlefield.

If an invention represents only a small step forward as compared with the known art in a given field, the world is readily able to follow in thought this small step, and the value of the invention is understood without difficulty. If, on the other hand, the invention represents a step in the evolution of the art, which is far removed from the last in the same series, then the world, and even the world of experts, often

* Translated for the Scientific American from *Technische Monatshefte.*

fails to follow the flight of the genius, and the inventor or scientific discovered reaps, instead of fame, only ridicule and scorn. It is only in later days, when a number of re-discoveries of smaller order have covered in a series of small steps the great advance which he had made in one, that the world at large realizes the greatness of the genius, who by this time is usually dead. In belated token of their appreciation the people then raise a monument to him who can no longer feel the pleasure of this poor compensation for the troubles and pains endured during his lifetime.

Mesothorium and Radiothorium

Substitutes for Radium

The development of radioactive investigations in recent years, and especially the increasing employment of radium and its emanation in medicine, have created a strong demand for radioactive substances which cannot be satisfied by radium itself. It is very difficult to produce radium in considerable quantities, owing to the scarcity of raw material. As substitutes for radium, the slowly disintegrating derivatives of thorium which are known as mesothorium and radiothorium naturally suggest themselves. In order to understand the possibility of such a substitution it is necessary to review briefly the chief properties of radioactive substances in general.

Radioactive substances are characterized by the property of emitting peculiar non-luminous rays which are recognized by three principal actions: the blackening of photographic plates, the production of fluorescence, and the discharge of electrified bodies. This discharge is produced by the power of the rays to divide the non-electrified molecules of air into positive and negative parts, called ions, which serve as conveyers of electricity. If an electrified body is placed in air ionized by the rays of radium, the charge is quickly lost. The quantitative study of radioactive substances is based upon this property.

The rays are of three kinds which are called Alpha, Beta and Gamma rays. The Alpha rays are streams of material particles which are positively electrified and are projected with a velocity of about 10,000 miles per second. This great initial velocity, however, is so rapidly destroyed by the resistance of the air that the particles can penetrate only a few inches into the air. In this short journey they exert an astonishing ionizing effect. When the Alpha particles strike a screen coated with zinc sulphide they produce a scintillation due to fluorescence. The investigations of Ramsay, Rutherford and others have proved that the Alpha particles are positively electrified atoms of helium. Every substance which emits Alpha rays is therefore a continuous source of helium.

The Beta rays, like cathode rays, consist of negatively electrified particles, the mass of which is about 1/1800 that of the hydrogen atom. Their velocity is nearly equal to that of light. Owing to their great velocity and small mass, the Beta rays are able to penetrate much deeper strata of air and thicker layers of solid substances than the Alpha rays; but, for the same reasons, they exert a much smaller ionizing effect in traversing an equal distance.

The Gamma rays are similar in nature to Roentgen rays. They easily traverse the human body and thick plates of metal, but their ionizing power is comparatively small.

The phenomena of radioactivity have found a satisfactory and fruitful explanation in the hypothesis of the disintegration of radioactive atoms, which was advanced by Rutherford and Soddy. According to this hypothesis, the atoms of radioactive substances are unstable and subject to continual decay. The Alpha and Beta rays are fragments of the disintegrated atoms. Radium, for example, emits Alpha rays, i. e., each atom of radium splits up into an Alpha particle, or atom of helium, and an atom of a new element which, owing to its gaseous nature, is called radium emanation. This emanation, in turn, spontaneously decomposes and produces a series of gradually disintegrating solid substances which are designated as active deposits. The last of these is the element polonium, which was discovered by Madame Curie.

Radium itself is a disintegration product of uranium which gradually changes into radium, passing through the intermediate stages of uranium X and the recently discovered ionium.

The time in which a radioactive substance is half converted into the next member of the series is called the half period or disintegration period of the substance. The various products of disintegration are sharply distinguished by their half periods as well as by their radioactive and other properties. The longer the period is, the more stable is the substance, and therefore the more useful for radioactive purposes.

The metal thorium is the first member of another radioactive series distinct from the uranium-radium series. Thorium and uranium are the two primary radioactive elements, from which all other radioactive substances are derived. (The very weakly radioactive elements, potassium and rubidium, the position of which is not yet definitely established, are not here **considered.)**

The disintegration products of thorium, the nature of their radiation and their half periods, are given in the following table:

Substance.	Radiation.	Half Period.
Thorium	Alpha	About 3 x 10 years.
Mesothorium 1		About 5.5 years.
Mesothorium 2	Beta, Gamma	6.2 hours.
Radiothorium	Alpha	2 years.
Thorium X	Alpha, Beta	3.6 days.
Thorium emanation	Alpha	54 seconds.
Thorium A	Beta	10.6 hours.
Thorium B	Alpha	55 minutes.
Thorium C	Alpha	About 1 second.
Thorium D	Beta, Gamma	3.05 minutes.

Of these products mesothorium (or the mixture of mesothorium 1 and mesothorium 2) and radiothorium are comparatively long-lived, so that it is possible to produce them in large quantities in strongly active conditions.

Prof. Otto Hahn, whose article in *Die Umschau* is here condensed, states that he obtained radiothorium in 1905 in Ramsay's laboratory in London, from the residues of thorianite, and gave it the name of radiothorium because it exhibited all known radioactive properties of thorium to a greatly increased degree. Elster and Geitel and G. A. Blanc simultaneously and independently discovered radiothorium in the mud of radioactive springs. If radiothorium is actually the radioactive part of thorium, thorium and radiothorium should be contained in proportional quantities in the various thorium ores. This is approximately the case, according to the experiments of Boltwood and McCoy. The investigation of thorium salts, however, led to the remarkable result that the activity of the salt is in general less than the quantity of thorium demands. Boltwood and Eve concluded from this fact that in the operations by which thorium or its salts are obtained from the ores, the radiothorium is partly eliminated. This would be very remarkable, in view of the fact that neither Boltwood and Eve, nor Hahn, was able to separate radiothorium from thorium by chemical methods. It was found, also, that the half period of radiothorium is about two years, so that a given quantity of radiothorium would be half destroyed in two years, but would be reproduced to the same extent from thorium. The weakly radioactive thorium salts investigated by Boltwood, however, did not increase in strength to the extent required by the foregoing considerations. Hence Hahn suspected the existence of an intermediate product between thorium and radiothorium, possessing a comparatively long period and chemical properties different from those of thorium and radiothorium.

Hahn then undertook a systematic study of various freshly prepared pure thorium salts and also of old thorium salts. He found that the radioactivity of the fresh salts was proportional to their percentage of thorium, but that the radioactivity gradually diminished. Preparations four years old were scarcely half as strong as fresh preparations. Still older preparations, on the contrary, showed increased activity. These phenomena can be explained by assuming that in the preparation of the thorium salts a hypothetical substance, intermediate between thorium and radiothorium, is eliminated, while the radiothorium already produced remains associated with thorium. In the absence of its hypothetical parent substance, the radiothorium gradually diminishes and the activity of the preparation would fall to zero except for the fact that the intermediate product is gradually regenerated. After a time, therefore, the quantity of radiothorium increases and the radioactivity increases with it.

If this view is correct, the hypothetical intermediate product should be found in the residues left in the preparation of the thorium salts, and there it was found by Hahn, who named it mesothorium. The discovery was confirmed by Boltwood and McCoy. Both McCoy and Hahn computed the half period as about 5.5 years.

Preparations were then made to obtain mesothorium in quantity from residues left in the commercial preparation of thorium salts. In this process it was necessary to treat enormous quantities of material, as appears from the following comparison. One milligram of radium bromide is about as active in penetrating rays as six kilograms of thorium oxide. The ordinary thorium ore, monazite sand, contains four or five per cent of thorium oxide, hence from 120 to 150 kilograms of monazite are required to produce a quantity of mesothorium equivalent to one milligram of radium bromide, even if no loss occurs.

The thorium residues are so abundant that strongly radioactive mesothorium preparations can be obtained by working up sufficiently large quantities. In this way about 250 milligrams of mesothorium equal in activity to pure radium bromide have already been produced, and a few milligrams of a substance four times as strong as pure radium bromide have been obtained. As radium bromide is about 6,000,000 times as active as thorium oxide, the mesothorium preparation just mentioned is about 24,000,000 times as active as thorium oxide, or 50,000,000 times as active as thorium nitrate, the ordinary commercial salt. The action of the strong mesothorium preparations is apparently identical with that of pure radium salts. This statement, of course, refers only to the more penetrating rays, as mesothorium does not emit Alpha rays. The Alpha rays of radium, however, are stopped by the ordinary glass container.

The production of mesothorium furnishes the possibility of obtaining radiothorium in very active form. It is found impossible to separate radiothorium from thorium, but it can easily be separated from mesothorium as fast as it is formed. If the radiothorium is not separated its action is added to that of the mesothorium. Radiothorium is similar in property to actinium which has been obtained only in very small quantities. Owing to the short life of thorium emanation neither radiothorium nor mesothorium is available for certain purposes for which the comparatively long-lived radium emanation is employed. It is possible, however, to separate from radiothorium the intermediate product, thorium X, whose period is about equal to that of radium emanation and which is a continuous source of the short-lived thorium emanation.

As the period of mesothorium is 5.5 years and that of radiothorium is 2 years, freshly prepared mesothorium preparation increases in strength for about three years, and by about 50 per cent, and then become weaker. The activity falls to its original value in about 10 years and to half that value in 20 years. The fact that the activity diminishes so slowly and never reaches zero, is due to the presence of a small quantity of radium derived from the uranium contained in the monazite. As mesothorium, like radium, belongs to the group of the alkaline earths the two elements remain associated.

The production of mesothorium and radiumthorium has the great disadvantage, compared with that of radium, that inordinately large quantities of material must be worked. One ton of uranium residues yields about one-third gramme of radium bromide, but one ton of thorium residues yields less than ten milligrams of a mesothorium preparation equal in strength to radium bromide. Nevertheless, mesothorium can be prepared more cheaply than radium, because uranium residues are valuable, while thorium residues can be had in large quantities and have hitherto been a waste product.

Germany is the largest producer of thorium in the world and is able to furnish, annually, a quantity of mesothorium equivalent to more than ten grammes of pure radium.

Ancient Roman Mining

Interesting discoveries have been made in the San Domingo mines of Spain that show the methods followed by the ancient miners.

In some of these mines the Romans dug draining galleries nearly three miles in length, but in others the water was raised by wheels to carry it over the rocks that crossed the drift. Eight of these wheels have been brought to light by men working in these same old mines. The wheels are made of wood, the arms and felloes of pine, and the axle and its support of oak, the fabric being remarkable for the lightness of its construction.

It is supposed that these wheels cannot be less than 1500 years old, and the wood is in a perfect state of preservation, owing to its immersion in water charged with the salts of copper and iron.

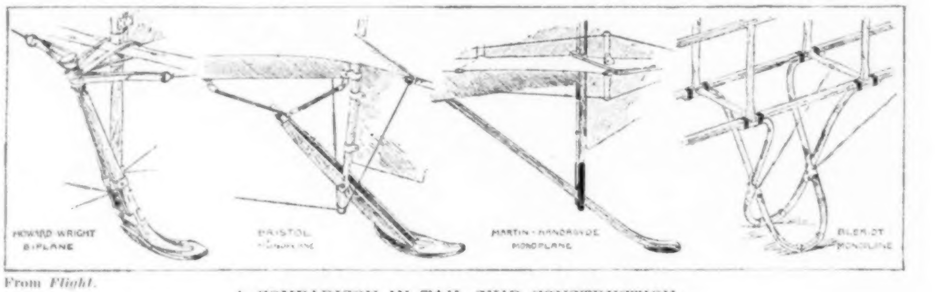
From their position and construction the wheels are supposed to have been worked as treadmills by men standing with naked feet on one side. The water was raised by one wheel into the basin, from which it was raised to another stage by the second wheel, and so on for eight stages.

Aeroplane Under-carriages.*

Some Recent Designs

No better example of the manner in which practical considerations relating to matters of an entirely extraneous character often affect the direct solution of theoretical problems could easily be found than may be observed in the influence of the under-carriage on the evolution of the flying machine. It is true, of course, that aeroplanes must always alight on *terra firma* sooner or later, but the ability to do so gracefully and harmlessly might at first have been far more conveniently deferred to a later date had it been possible to do so, in those days when the ability of a machine to fly at all was the main question of importance. However, nowadays the marked success of passenger-carrying vehicles of the air, and the rapidly increasing evidences of a more or less immediate definite utility in aerial navigation, demand the fitting of perfected landing arrangements, and the time and care bestowed upon the design of the under-carriage no longer seems out of place. From the very beginning, however, necessity forced this same purely mechanical problem on the attention of those who sought to fly. The inventor might have ideas galore, but before he could test the least of them it was always necessary to come down to earth in order to undertake the practical design of some suitable supporting member capable of preserving a machine during its all too protracted peregrinations on the ground. All kinds of different schemes have been tried at one time or another. Sir Hiram Maxim built a railway for his immense aeroplane of 1893. Langley built launching ways over the waters of the Potomac for his double tandem monoplane, which might well have been the first machine to fly in America. Lilienthal and the early pioneers of gliding carried their machines under their arms so that they might use their own legs for starting and alighting. The Wright brothers, who, having adopted the prone position on their gliders, used to have their machines carried by assistants for the purpose of launching, subsequently improvised a single starting rail when they developed their power-driven flyer. All special devices such as these served their purpose for the time being, and to the extent that as they were used they were justified by the facility that they afforded the experimenters to get ahead on the real purpose of their undertaking, which was to learn something about the dynamic navigation of the air. It was always obvious that so soon as the practice of the art of flying should attain to any measure of popularity that the aeroplane of that day would have to be a self-contained machine capable of safely rising from and alighting on the ground by means of its own under-carriage.

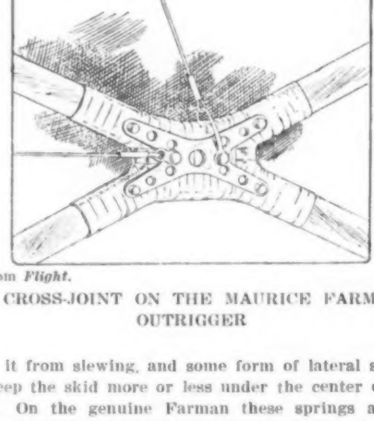
Considering the nature of early aerodromes and the conditions of the ground on which pilots must at all times be prepared to bring down their machines, it is really remarkable how satisfactory the simple and somewhat crude designs have proved to be. Nothing could well be less complicated than the conventional Farman type of wheel and skid combination that has been popular for over a twelvemonth. Examples of it may be seen on the Bristol biplane, Grahame-White biplane, Howard Wright biplane, Baby Wright biplane and Dunne monoplane. Each of these machines has, except possibly for minor details, the conventional form of this type of under-carriage, from the two strong ash skids placed well apart to give a wide base of support and trussed by vertical and oblique struts with wire bracing to the main spars of the lower plane. Each skid carries a short steel axle on the extremities of which are mounted two wire-spoked pneumatic shod wheels. The axles are lashed at their centers to the skid by an elastic strap, which forms the sole flexible suspension in the system. If these elastic springs break the machine settles down on the skids proper, but so long as the elastic holds the weight is carried by the wheels. Under the tail plane is a small skid to protect the tail plane from coming in contact with the ground. It is a minor and comparatively insignificant structural feature, but a study of its details often reveals many points of interest. In respect to the mounting of the axles to the skids on the Farman type under-carriage, the design generally only varies in minor details, for all the examples include, in addition to the main elastic springs, a pair of steel tubular radius-rods that tie the extremities of the axle to the skids so as to prevent it from slewing, and some form of lateral spring to keep the skid more or less under the center of the axle. On the genuine Farman these springs are of the steel helical type and surround the axle. On the Bristol biplane elastic strips are used to tie the extremities of the axle to the skid instead.



From *Flight.*

A COMPARISON IN TAIL SKID CONSTRUCTION

A similar arrangement carried out in a particularly neat manner is employed on the Howard Wright biplane, where can be seen an excellent example of the accepted method of attaching the supporting brackets for the main elastic springs. In most cases the tubular radius-rods are fastened to the skids by a bolt passing through the angle plate, but on the Grahame-White under-carriage this bolt is replaced by a U staple.



From *Flight.*

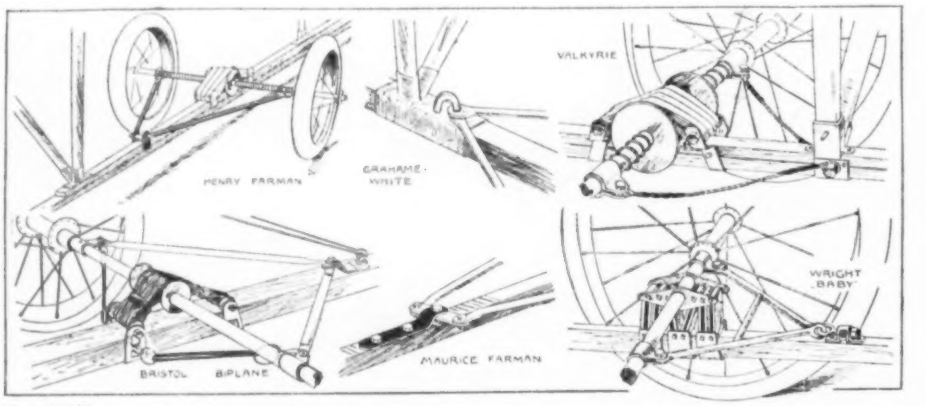
A CROSS-JOINT ON THE MAURICE FARMAN OUTRIGGER

The Valkyrie monoplane, which has the Farman type wheels and axles on an under-carriage of entirely original design, illustrates an example of the steel helical lateral spring, and is further interesting on account of the use of stranded steel cables in place of rigid tubular steel radius-rods. On the Baby Wright biplane the elastic spring differs from the ordinary type, for here the axle carries a bracket fitted with parallel bolts, three on either side of the axle, and each bolt carries a separate broad elastic band that is anchored to the corresponding member on the skid. The radius-rods on this very neatly constructed carriage, too, are brazed together so as to form a rigid A-shaped member, the apex of which is flexibly attached to the skid by an eye-bolt.

In all machines mentioned the skids themselves are fairly short, with more or less upturned extremities projecting a matter of perhaps 3 feet in front of the main planes. On the Maurice Farman aeroplane the under-carriage is distinguished from the Henry Farman by the continuation of the skid members as far as the elevator outrigger, on the lines originally introduced by Sommer. The Humber biplane is another example of this form of construction, but in this particular machine the skid extensions form separate pieces fastened in place by bolts to the skids proper, whereas on the Maurice Farman the skid is continuous. This Maurice Farman carriage is also particularly interesting on account of the joining in the outrigger framework of which the skid forms a part.

The other outstanding examples of this principle of carrying the skids right forward to the elevator are to be found in the Valkyrie and the Sanders aeroplanes, the former being an altogether distinctive type of under-carriage due to the peculiar nature of the machine itself. It is interesting, however, to compare the Valkyrie with the Sanders, in which the principal members of the under-carriage consist of two very strong girder type skids braced by wood struts and diagonal steel tape. In the Sanders biplane the under-carriage is distinctly a self-contained unit, whereas in the Valkyrie, where the same general principle is in use, the carriage seems to be so much more an incorporated part of the machine as a whole. It is not easy to suggest an alternative method by which the Valkyrie machine could be put together without a carriage of its present form, and this, after all, is some indication of a homogenous design.

In all machines thus far compared the under-carriage has been characterized by the presence of two skids and four wheels, but among monoplanes it is uncommon to find more than a single axle, in conjunction with a central skid. An excellent example of this form of construction may be observed in the Handley Page monoplane, which has a central skid of channel section timber and a very long axle, also of timber, the flexibility of which constitutes the suspension. Above the axle rise two masts forming an A-type frame for the support of the fish-like body, and it may be observed that this frame is continued right through the body to form a mast for the bracing of the wings. In the Bristol monoplane, which is likewise characterized by a central skid and single axle, the body is supported by a pair of inverted A-type frames, the apices of which rest upon the skid. On this machine, however, the axle is not so long and elastic suspension is employed as a means of attaching the axle to the skid. On the Handley Page monoplane these two members are rigidly connected. Another feature of the Bristol monoplane is the use of two long crutches to form struts between the extremities of the axle and the upper beams of the body, to which they are attached by elastic shoulder straps. Another interesting comparison with both the above-mentioned carriages is afforded by the Nieuport, which is similar in principle to the Bristol, in so far as the body is attached to the skid by two inverted A-type frames, but differs from both the Bristol and the Handley Page, in having a tubular steel skid and an axle that is formed by a laminated steel spring. In the flexibility of this spring the axle is obviously similar in principle to that on the Handley Page.



From *Flight.*

COMPARATIVE DETAILS IN THE CONSTRUCTION OF THE FARMAN TYPE WHEEL AND SKID COMBINATION

*Reprinted from *Flight.*

Yet another variation in the central skid category is the class that is formed by machines like the Antoinette, in which the axle and skid are entirely independent structures, the skid taking the form of a projecting foot under the fore part of the machine only. An example of this system of construction more or less as introduced on the Antoinette is to be seen on the Martin-Handasyde monoplane, where, however, the suspension of the axle itself embodies many original details. In this machine the weight is carried on four elastic springs that are grouped round the central tubular steel column situated vertically beneath the body. On this column slides a cross head, to which the springs and diagonal struts of the axle are anchored, and a corresponding cross head at the base of the column forms the point of attachment of the inner ends of the divided axle itself. A modification of the original Antoinette combination is represented by the Kny aeroplane, in which the foot-like skid is hinged to the axle; but this particular carriage is, properly speaking, in a category by itself, because the axle is rigidly trussed to the body, and the wheels are mounted, too, on the axle by radius brackets fastened by coil springs. A massive wooden foot is attached to the body by a telescopic strut fitted with a helical spring buffer.

The Cody biplane also belongs to the central skid type of carriage. In this machine the axle is unusually short and guard wheels are fitted to the extremities of the lower main planes on that account. The suspension on this machine is effected by two very large and very long helical steel springs, which extend from the axle to the main frame, and when the machine is in flight the thrust of these springs is transferred from the axle extremities to the diagonal wires that brace the forward main spar in the lower plane.

The most elaborate looking carriage of all is that on the Bréguet biplane, which really constitutes a three-wheeled under-carriage, on which the machine is entirely supported, for there is no protective skid under the tail. Two of these wheels, all of which are of very small diameter, are mounted on the extremities of a rigid axle that is attached to the body by two telescopic struts fitted with helical spring buffers and oil dashpots. This axle also carries two short skids projecting forwards, and the front ends of these, which are normally quite clear of the ground, are fastened to the same point of the body by rigid tubular steel struts. Between the base of these latter struts is another tubular steel axle forming part of a horizontal triangular frame, at the forward apex of which is a wooden foot. The foot is hinged to the frame, and a rearward extension thereof carries the third wheel of the set of three on which the machine is mounted. This wheel occupies a position in the center of the afore-mentioned triangular framework, and being interconnected with the steering mechanism, may be moved anywhere within the space thus defined. The forward apex of the frame is, like the main axle, attached to the body by a telescopic strut.

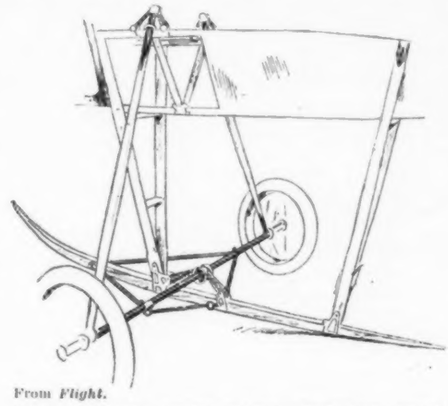
A machine that stands in a class apart, so far as its carriage is concerned, is the Blériot, which has been little altered except in the matter of refinement since it was initially designed. In this machine the carriage is primarily a rectangular frame formed by top and bottom flat beams separated by two vertical struts, and carrying between the extremities two vertical tubular steel columns. The body rests on the top beam, while the lower beam forms the base of the structure and the point of attachment for the steel tapes that truss the wings. Attached to the steel columns are hinged triangular brackets that support the wheels, the hubs of which are tied together by an ash strut and braced diagonally to the base of the carriage by wires anchored to rubber springs. This latter construction is for the purpose of keeping the wheels in line with the direction of motion. Additional struts rise from the base of the carriage to assist in the support of the engine frame, which is situated in front of the body, and also for the support of the body at a point farther to the rear, but on this machine there is no skid of any description other than the simple little bamboo cross beneath the tail.

Our Iron Ore Reserves

A COMPREHENSIVE review of the situation with regard to the supply of iron ore in the future forms part of Prof. J. A. Kemp's paper, "Geology and Economics." The data are of such interest that a somewhat detailed quotation seems to be in place, and is given below:

"In 1905 Prof. Törnebohm, the eminent and greatly esteemed former director of the Geological Survey of Sweden, assigned to us a reserve of only one billion and sixty millions of tons. Obviously, at an annual production of over fifty millions this reserve would only last twenty years. Much opposition arose at once, however, to Prof. Törnebohm's data, because from them had been omitted the red hematites of Alabama, which can be very accurately estimated, and which of themselves are thought by competent observers to have a half-billion tons for the future. Additional modifications must also be introduced when we properly appreciate the downward tendency of workable percentages. The lower the percentage of iron which we require in the product of our mines, the greater the amount of ore which at once becomes available. This is peculiarly true of iron, because of its very wide, general distribution.

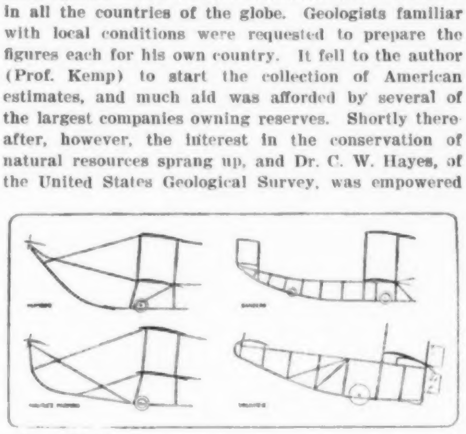
"In 1907, in anticipation of the International Geolog-



From *Flight*.

THE BRISTOL MONOPLANE SHOWING THE CRUTCHES

ical Congress of 1910, which was to be held in Stockholm, the Swedish committee of arrangements began the preparation of a series of estimates of iron reserves in all the countries of the globe. Geologists familiar with local conditions were requested to prepare the figures each for his own country. It fell to the author (Prof. Kemp) to start the collection of American estimates, and much aid was afforded by several of the largest companies owning reserves. Shortly thereafter, however, the interest in the conservation of natural resources sprang up, and Dr. C. W. Hayes, of the United States Geological Survey, was empowered



From *Flight*.

A COMPARISON OF SOME GIRDER SKIDS

to use all the resources of this great organization in assembling data on iron. In this way figures as reliable as can be expected are now available. We learn from them that we may consider three and one-half billions tons of 50 per cent ore as assured in the Lake Superior region. Of this great total three billions, one hundred millions are in the Mesabi range of Minnesota. At thirty millions of tons per annum, the present output of Minnesota, we have a reserve for a century.

"On the other hand, if we drop to 40 per cent or slightly below, still, however, remaining a few per cent above the Alabama grade, the drill holes show above depths no greater than those already reached in some mines, two or three hundred billions of tons of siliceous hematites, giving amounts practically inexhaustible.

"In the Alabama ore beds we feel assured of five to six hundred million tons of the grades now utilized, and there may well be twice that number. The conservative estimate would afford enough to last at the present output of that State longer than a century. In addition there is much reason for thinking that there may be two or three times as much.

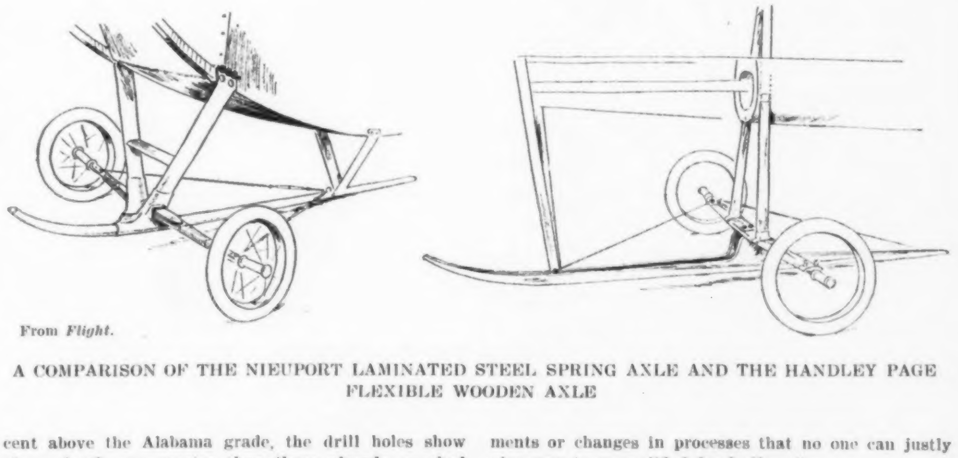
"Speaking for the country as a whole, we may say that there is an assured and demonstrated supply, at present rate of output and at present percentage of yield, for about a century. There is, furthermore, a less accurately measured but still very probable addition, when we allow for lower grade but still practicable ores, which will be sufficient to last at present rate of production for fifteen hundred years to come.

If, however, production increases, as indeed it may with a rapidly growing population, and if in this way heavier and heavier drafts are made upon even this great reserve, where shall we look for more? There may be some new discoveries within the United States, but at present it is impossible to speak definitely of them. We may ask if there are other supplies in neighboring lands. To this question we may answer yes. Along the north shore of Cuba, toward its eastern end and near the sea, three areas of what formerly appeared to be a barren, ferruginous soil have been discovered and tested, so that we now know that there are two to three billions of tons of a very pure iron ore, which, when deprived of the large percentage of water which it contains—a cheap and simple process—will yield from 40 to 45 per cent iron. This variety of ore already begins to enter our ports, and the deposits will undoubtedly contribute in no unimportant way to the output of our furnaces.

"The report of the International Geological Congress has shown further that in Newfoundland there are very probably more than three billions of tons of red hematite, whose present yield averages 54 per cent. From Brazil, moreover, in the State of Minas Geraes, but pretty well back from the coast and not yet opened up by rail, as estimated by Dr. O. A. Derby, there are from five to six billion tons of 50 to 70 per cent ore awaiting the drill and the steam shovel. Ore from Brazil faces a long sea voyage, but the grade is rich and the iron masters of this and other countries are looking upon these deposits as well within the possibilities of the future. Ocean freights are kept at very reasonable rates in later days, and once on a steamship even so low-priced a commodity as iron ore, if of good percentages and cheaply mined, can be taken relatively great distances. This is demonstrated by the shipment this year from the mines of Kiruna, 112 miles within the Polar Circle in Lapland, of 300,000 tons of ore, 113 miles to the Norwegian coast by rail, and over 4,000 miles to Philadelphia by sea, with no great prospect of a return cargo. These shipments also demonstrate that we are not without the range to which European ores may be shipped when exceptionally rich. Some portion of the vast ore body of Kiruna, with its demonstrated 500 millions of tons of 65 to 69 per cent ore, will also reach American furnaces.

"But even were our actual ores of present grade to become exhausted, iron as a metal would not fail. The basic rocks with their low percentages still remain. The traprock of the Palisades contains 7 to 8 per cent of metallic iron, a value that is far above the general yield of our copper ores in the red metal.

"Iron, therefore, will never fail. It will probably not change in its general relations to modern conditions for a very long time to come, so far as its ores are concerned. We may have greater anxiety about the supplies of coking coals than about the iron or but there are always such possibilities of improvements or changes in processes that no one can justly give way to unqualified forebodings."



From *Flight*.

A COMPARISON OF THE NIEUPORT LAMINATED STEEL SPRING AXLE AND THE HANDLEY PAGE FLEXIBLE WOODEN AXLE

Stone Paste for Casting.—Boil linseed oil with paper waste or bookbinders' paper trimmings for 24 hours. Pour the mixture into molds. Dissolve glue in hot water; mix the solution with linseed oil, washed chalk and paper pulp.

Mechanical Handling of Materials*

The Progress of Recent Years

By Richard Devens

Within the last few years some of our railroad, industrial and steamship companies have begun to realize the important part mechanical transference plays in the quick and economical handling of material. The most efficient advances have been made in the handling of bulk material, such as ore, coal and grain, while package freight, comprising boxes, barrels, bags and other packages, which make up the load of a freight car, or the cargo of a steamship, has just begun to receive serious consideration.

EARLY ADVANCES IN IRON ORE HANDLING.

It is no doubt a fact that the proficiency in handling bulk material was due to the difficulties to be overcome in the transportation and handling of iron ore to the center of the iron industry. I have reference to the iron ore that was discovered in the Lake Superior country. The first problem was the transportation, and this was overcome in 1855 when the Federal Government completed its first system of locks at the falls of the St. Mary's River at Sault Sainte Marie, Mich. The second problem was the loading and unloading of the vessel. The loading was readily accomplished by the building of a long line of pockets on a dock extending into the lake and the equipping of each pocket with chutes. The pockets were of such height that the ore would flow from them over the chutes and into the vessel by gravity. The railroad cars, of the bottom dump type, were brought over the top of the pockets and dumped into them.

It is interesting to note that the method used in the first loading dock is the one on which all docks have been constructed since. The unloading has been the most difficult to accomplish in a quick and economical manner. The first vessels to carry iron ore were not constructed for the purpose, and while they carried some ore in the hold, most of it was carried on deck. When it was carried in the hold, it was hoisted to the deck by horse power, dumped into barrows; and then, like the deck cargo, wheeled ashore.

The next step was the substitution of a small hoisting engine for the horse power. This early method was in operation many years, and it was not until the dock managers were forced into it by the great expense in carrying large storage on the dock, that any mechanical devices were attempted.

THE FIRST MACHINE FOR ORE LOADING.

A cableway machine, built and erected at Cleveland, Ohio, in 1880, under Alexander E. Brown's design and supervision, was the first mechanical plant. The next machines were of the bridge type. The method of handling the iron ore, over either the cableway or bridge, was to fill iron buckets by hand in the hold of the vessel and then hoist them by the machine, and dump them automatically into railroad cars or storage. In the hold there were from 12 to 15 shovelers to each machine, and there were two men on the machine, one an operator and the other a fireman.

Both of the above equipments were a great improvement over the early methods, and handled the iron ore in a satisfactory manner; yet they did not cut down the cost of the hand labor in filling the buckets in the hold. This was a very large part of the cost of unloading. An automatic filling bucket had been worked successfully for a number of years in coal and similar soft material, but on account of the hard and lumpy nature of the early iron ores it could not be operated in them.

THE GRAB BUCKET MACHINE GREATLY LOWERS COST.

With the use of the soft Mesaba ores, interest in the automatic filling or grab bucket was renewed, and about ten years ago the first successful grab bucket machines were erected and operated at the Illinois Steel Company's plant at Chicago by Hoover & Mason. This plant was designed to unload from the vessel direct into railroad cars. The success of this plant was the beginning of the present methods of unloading iron ore. There have developed two types of grab bucket machines—one with the grab bucket suspended from wire ropes and the other with the grab bucket carried on a rigid arm.

The cost of filling the buckets by hand was about 13 to 15 cents per gross ton, and the cost of hoisting and dumping into railroad cars or storage from 1½ to 2 cents per gross ton, making the total cost of unloading from 14½ to 17 cents. With the grab bucket machines, this total cost has been reduced to from 1 to 2 cents per gross ton, depending on the distance the ore is carried from the vessel.

The hand-filled buckets were of about one ton capacity, as this size had been found to be the most practical for filling and handling in the hold. With the grab bucket the size is only limited by the dimensions of the hatch and the shape of the vessel. The first grab buckets for iron ore were of five tons capacity, but since then machines have been built to handle seven and a half, ten and fifteen tons.

Besides reducing the cost of unloading, the ability to handle in larger units has reduced the time. Whereas with the hand-filled buckets to unload a 6,000-ton vessel was a question of days, it is now only a question of hours. The steamer Morgan of the Pittsburg Steamship Company, with a cargo of 11,319 tons of ore, was recently unloaded at Fairport in five hours and fifty-eight minutes. The work was done with six Brown electric unloaders.

INCREASED NUMBER OF VESSEL TRIPS.

These improvements have also increased the earning capacity of the vessel by making possible a greater number of trips during the season. This is seen in the following comparative statement for the years 1906 and 1910, showing the average stay at upper and lower ports of the vessels of the Pittsburg Steamship Company:

	Year 1906.		Year 1910.	
	Hr.	Min.	Hr.	Min.
Average stay in lower lake ports.	36	15	22	22
Average stay in upper lake ports.	22	25	12	22
Average time spent in port receiving and discharging cargoes...	58	38	34	44
	Gross Tons.		Gross Tons.	
Average cargo carried...........	5,954		6,634	
Largest cargo carried...........	13,333		13,296	
	In 70 Min.		In 45 Min.	
Fastest loading record..........	9,277		9,785	
	Tons per Hr.		Tons per Hr.	
Rate of fastest loading record...	7,288		13,051	

EUROPE AHEAD IN HANDLING PACKAGE FREIGHT.

In the foregoing I have outlined the development of handling bulk material, using iron ore as an example. The handling of package freight has not been brought to the same degree of perfection. In many manufacturing concerns mechanical devices have been installed to reduce the cost of handling and to hasten the transportation of their products, but for quick and economical handling of freight at shipping docks and railroad terminals little has been done in this country. In Europe greater advances have been made, due largely to the encouragement given by the city or government, which frequently itself equips the docks. At Hamburg, Antwerp, Bremerhaven, Glasgow, London, Manchester, Havre, and many other ports are found mechanical appliances, each to meet the local requirements, but all aiming to reduce the number and cost of handlings.

In England at the freight stations and warehouses the practice is to instal jib cranes, so arranged that they can serve all the floor space from car or wagon. In this country many of the railroads have put in hand cranes of the pillar or bridge type for handling freight from cars to wagons or *vice versa*, but they are mostly for heavy lifts, and are slow in operation and cover only a limited area.

Some of the railroads have put in electric cranes in their freight yards and water terminals; for example, the Pennsylvania Railroad Company on its Greenville docks, the New York Central & Hudson River Railroad Company at Port Morris, the Philadelphia & Reading Railroad Company at Port Richmond and the Central Railroad of New Jersey at Communipaw.

PACKAGE FREIGHT AT TERMINALS.

Many of the railroads are coaling their locomotives at greatly reduced cost and time by mechanical appliances, but the question of handling their package freight at terminals is still open. Most managers have known that there is a great loss of time in transferring freight at terminal and intermediate points, but few seem to realize the high costs that this involves.

Perhaps the most complex movements in the handling of package freight are at the large steamship piers, due to the great carrying capacity of the large vessels, the many consignees, each having his allotted space, and the limited floor area that has to be cleared quickly to make room for the next vessel. The larger railroad terminals also have their many consignees, but the floor area is not so restricted.

The placing of the packages in the proper space is done by the hand truck. A sling load from the vessel or a railroad car may contain packages for several consignees. The track man cannot wait to sort as he receives them, so must load his truck with them as they come. This means a long travel to get the packages to their allotted space. In order to tier them, several more handlings are necessary. All this leads to congestion and increasing cost per ton. This is further affected by the rise in the cost of labor, materials, rent and larger terminals. Each terminal is a problem in itself, as is each manufacturing establishment, so that it is necessary to make a careful study of the conditions to be met before any mechanical method can be proposed.

In the last thirty years there has been a steady increase in the capital invested in manufacture, which means an increase of tonnage of all kinds of package freight carried by the steamship and railroad companies. To meet this, the railroads have increased their rolling stock and either enlarged their terminals or built more. In large cities this has been at great cost for land and buildings. The method of handling the freight has remained the same.

At a terminal there are two kinds of freight—outbound and inbound. The outbound is transferred from wagons into the outbound freight house, and thence to the railroad cars or directly from the wagons to the cars. The inbound is *vice versa*.

All the above movements, except between wagons and cars, involve the sorting of packages and distributing each to its designated space. It is also necessary to transfer cars from one freight house to the other, as the use of the hand truck necessitates bringing the cars to the freight.

REQUIREMENTS IN FREIGHT HANDLING.

A mechanical equipment to be satisfactory must be able to distribute the outbound and inbound freight simultaneously; there should be no rehandling, and every square foot of floor space should be served with a single handling. All motions of lifting and conveying should be done by power. The machinery should be designed to give the greatest lift required and to transfer to any reasonable distance and then tier or lower into cars. Continuous operation should be sought for to avoid delay.

No part of the transference should be along the floor, and the equipment should not take up any floor space that can be used for other purposes. All movements of the mechanical equipment should allow of the assorting and distributing according to classification and allotted space readily and quickly. There must be reserve capacity to prevent congestion in case of extra demands. The justification for the investment of the mechanical installation lies in the reduction of cost and the saving of time in handling. The expense should be in proportion to the size of the terminal.

There are many companies in this country engaged in the manufacture of hoisting and conveying machinery. While perhaps no one makes all the necessary appliances, yet a combination of their product could be used to fill the special requirements of each terminal point.

HOW TO MEET THE PROBLEM.

Fully to cover the floor space and obtain all the different requirements for the satisfactory handling of the package freight, three units or different types of conveying machinery are necessary. These are the single rail electric trolley, the bridge traveler and the cross traveler. The electric trolley is the actual load carrying part of the equipment, the single rail, bridge traveler and cross traveler furnishing a combination of loop track system on which the trolley can reach any part of the area to be covered. All movements should be so regulated that there will be no interference, and many trolleys can be in operation following one another. Each trolley can draw a number of trailer trolleys, so that many packages can be hoisted and transported under the control of one man. This arrangement allows many loads to be transported in close sequence simultaneously, and with maximum hoisting and traversing speeds, gives the greatest range and capacity at a minimum of labor and maintenance. At some freight terminals it may be necessary to have, in combination with the above

*Presented before the Congress of Technology, Boston, April 11th, 1911, at the fiftieth anniversary of the charter of the Massachusetts Institute of Technology.

mechanical conveyors, motor trucks on the surface; in others, belt conveyors. There is no doubt that some such scheme as outlined above, when properly carried out to meet the special requirements at any terminal, would materially reduce the time and cost involved in the present method. This has already been exemplified in the handling of bulk material.

Considering the special attention now being given this question by several engineers and the interest shown by many steamship and railroad managers, it can be safely stated that within the next few years great changes and developments will be accomplished.

A New Gas Machine

Use of Gasoline for Production of Gas for Light, Power and Heat

THE consumption of gasoline and benzine has increased enormously during the last few years, and as this is in coincidence with the boom in the automobile industry, it was assumed erroneously that this extended use was merely due to this fact.

Especially during the last ten years, petroleum and its by-products, gasoline and benzine, have been used extensively for lighting purposes, either in a crude way by burning it in liquid form, or by turning it into gas by applying heat to a specially constructed carbureter, which usually is applied to each lamp.

Another manner of using benzine for producing gas, was in the introduction of gas machines which made gas by compressing air, the latter being forced over big areas of benzine or gasoline, until it saturates with the vapor of the benzine and forms in this way a burnable gas.

Just as simple as the production of the gas appeared, just as difficult was it to get this fluid of an always uniform quality. This condition arose from the peculiar qualities of the benzine, which is not a homogeneous chemical body, but only a mixture of different components of the hydro class, which according to their origin or place of destination are more or less volatile; therefore, it is only natural that the air passing over the benzine first takes up the more evaporable parts, and leaving the heavier, of which the air only can absorb a little, and therefore, the carburization becomes imperfect. The gas thus becomes steadily poorer in benzine vapor and in calorific value, and as soon as fresh benzine is added, the amount of hydro vapor is suddenly increased in the gas, which causes the burners to emit a smoke or very big flame.

For the technologist, the task was to produce an air gas which per cubic foot contains an exact determinable and constant amount of hydro-carbon vapor, and this quantity must be of such a low percentage that the gas, even in winter, could be used in extended pipe conduits without danger of condensation.

Let the gas be compared with the dew in the atmospheric air: It is well known, for instance, that air at 50 deg. F. can intake and embody more water steam (H_2O) than air of 200 deg. F., and if saturated air of 50 deg. F. is conducted into a room of only 20 deg. F. condensation occurs. It is very much like this with the air or gasoline gas. The tension of a liquid at a certain temperature allows figuring out how much vapor of the liquid a cubic foot or cubic meter of air can take up.

The benzine which is usually used for gas production has a specific gravity of 0.640-0.670, and its main components have at 32 deg. F. a tension of about 71 millimeters, at 10 deg. F. 90 millimeters, and at 50 deg. F. 115 millimeters; but we get the percentage of volume the air is able to take up by applying the following formula:

$$V = \frac{P \times 100}{700}$$

wherein P means the tension of the liquid to be gasified at a certain or given temperature. Hence, for instance, at 32 deg. F. the air is able to take up 137 grains of benzine vapor per cubic foot, therefore, the gas of such a composition could be used at a temperature down to 32 deg. F., but would condense below this point.

By embodying 107 grains of vapor in a cubic foot of air, gas is produced which remains constant at a temperature of 20 deg. F., and this composition is usually satisfactory to suit the average atmospheric conditions, for the simple reason that an extended pipe system (town piping, for instance), always must be placed below the frost line, and as a rule moving gas never will assimilate the temperature of its environments, or will be much affected by the temperature.

It is understood that the amount of benzine to be mixed with the air could be reduced further, but it is not advisable to do so, as with this decrease of benzine vapor, the calorific value of the gas would decrease. The gas of the above consistency contains about 7.7 pentane, 72.9 nitrogen, 19.4 oxygen, and develops about 340 B. T. U. per cubic foot, to which 18 to 20 per cent in efficiency should be added for the reason that the small amount of H_2O the gas develops when burned, increases the intensity of the flame.

The specific gravity of the gas is 1.12, and the table below, taken from the report of a highly recognized authority, gives a comparison between different kinds of light, showing the air required to get a perfect combustion and the products derived from it:

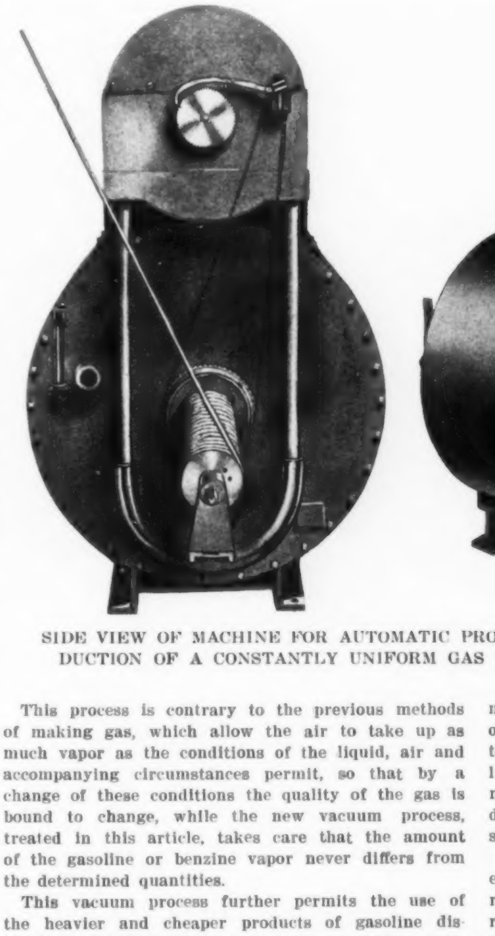
	Quantity, Liters.	Candle-power.	Air Required, Liters.	Product of Combustion.		
				CO_2	H_2O	N_2
Standard gas...	100	58	211	38	46	246
Coal gas	100	40	625	50	150	500
Acetylene	30	40	375	60	30	300
Petroleum	1/5	50	2,125	272	337	1.700

Note.—28¾ liters are equal to 1 cubic foot.

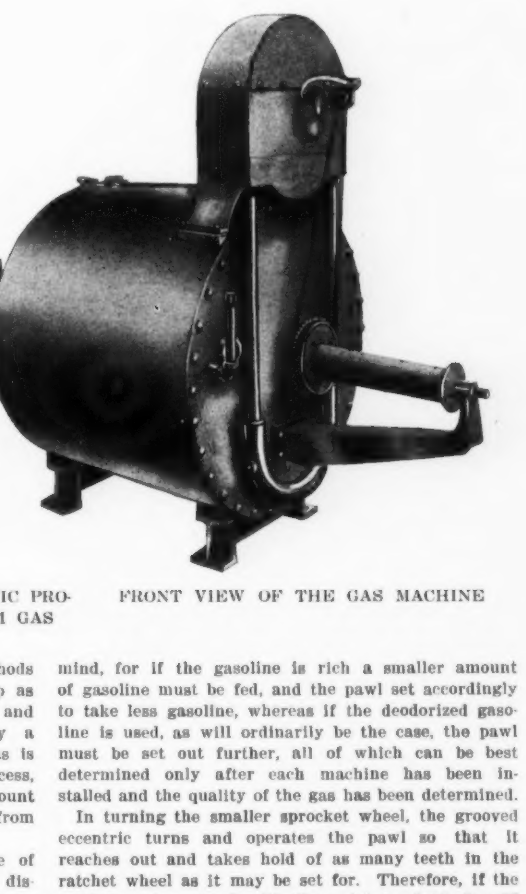
The principal idea of the gas machine shown in the accompanying illustrations and its process of making gas, consists in: To drop exact measured quantities of gasoline or benzine into a rarefaction room (carbureter), where it evaporates, and after this to mix the same with exact measured quantities of atmospheric air and to bring both together under a certain pressure which is necessary to conduct the gas to the burner, etc.

of the latter, and the temperature conditions. The oil is fed into the carbureter in the following manner:

The turning of the sprocket wheel connected with the windlass operates the small upper sprocket wheel by means of the endless sprocket chain. As this latter sprocket wheel has but nine teeth, it makes six revolutions while the windless makes one. To the axis of the sprocket wheel is fastened an eccentric which is grooved, and into this groove an arm or pawl is adjustably fixed by a set screw. This pawl or arm reaches over and engages with its point, a ratchet with about 150 teeth. This ratchet operates and controls the interior sprocket wheel which carries an endless chain of buckets. These buckets each contain an exact graduated quantity of oil, and therefore bring a uniform quantity of fuel up from the bottom of the reservoir, or return bent, as the case may be. One complete turn of the ratchet wheel, and consequently of the bucket sprocket wheel, would empty a certain number of buckets. By sliding the pawl in, one can regulate the number of teeth it will reach out and take. This is a valuable point to bear in



SIDE VIEW OF MACHINE FOR AUTOMATIC PRODUCTION OF A CONSTANTLY UNIFORM GAS



FRONT VIEW OF THE GAS MACHINE

This process is contrary to the previous methods of making gas, which allow the air to take up as much vapor as the conditions of the liquid, air and accompanying circumstances permit, so that by a change of these conditions the quality of the gas is bound to change, while the new vacuum process, treated in this article, takes care that the amount of the gasoline or benzine vapor never differs from the determined quantities.

This vacuum process further permits the use of the heavier and cheaper products of gasoline distillation—deodorized gasoline, common motor gasoline, etc., which cannot be used in any other gas machine.

In appearance the machine differs from those of other systems, inasmuch that the carburization and the pressure process usually and for convenience take place at one time in the machine itself, while in the other systems evaporization and pressure are two different operations.

It might be added, however, that the construction of the machine allows of transferring the twin operations to the outside of the building (outside carbureter) should conditions require it.

After the machine is wound up, the sprocket wheel of 54 teeth, attached to the outer circumference of the casing inclosing the planetary gears, revolves with the inside drum. One revolution of the windlass unwinds about 10 inches of cable and causes one revolution of the inside drum, making about 5 to 6 cubic feet of gas. To impregnate 1 cubic foot of air requires but a few grains of gasoline, according to the quality mind, for if the gasoline is rich a smaller amount of gasoline must be fed, and the pawl set accordingly to take less gasoline, whereas if the deodorized gasoline is used, as will ordinarily be the case, the pawl must be set out further, all of which can be best determined only after each machine has been installed and the quality of the gas has been determined.

In turning the smaller sprocket wheel, the grooved eccentric turns and operates the pawl so that it reaches out and takes hold of as many teeth in the ratchet wheel as it may be set for. Therefore, if the pawl is not engaged with the ratchet wheel, it will not turn the same, and will cause no feed of gasoline, and consequently neither gas nor light is given out.

If we find, by practical use of each installation, that there is a sufficiently rich gas when the pawl reaches out and takes 14 teeth, it will be seen that one revolution of the windless and consequently of the drum makes the sprocket wheel revolve 6 times and reach over, therefore, through the medium of the pawl and the take, 6x14 teeth, or 84 in all, are engaged in one revolution of the drum, which would figure down to 84/132 turn of the ratchet controlling buckets sprocket wheel, or 14 buckets containing about 500 grains of gasoline for 5 cubic feet of gas. It will further be seen that from 1 to 22 teeth can be engaged by the pawl, and here lies solely the regulation of gasoline feed. If your gas is too rich, you can set for less teeth, also if not rich enough for more, but this regulation will be done but once, and then the gas will be forever uniform, provided always that the same quality of gasoline is used.

Moving Houses in Germany

An American Idea Transplanted

By A. F. Bock

The moving of solid brick houses from one place to another is no longer an unshared privilege to America, since recently this has been successfully effected in Germany, at premises, Nos. 8 and 9 Seestrasse, in South Berlin, on each of which stood a two-storied solid brick house. Not proving profitable, the owner of the structure, on the advice of Mr. Richard Stephan, a resident architect, decided to move one of the villas, standing somewhat in the background, to a place just behind the other. When this was completed, the ground at No. 9 was free to be sold for building purposes.

After the concession for this scheme had been granted by the authorities, the work began. First of all the walls of the house to be moved were wedged in slowly and by piecemeal immediately above the foundations, and in the open spaces, broad-flanged "Differdinger"-beams N. P. 24 were cautiously inserted. For each wall two of these beams were used. Then timber beams of 21x24-inch diameter, the surface of which was mounted with 10-millimeter (0.394-inch) sheet iron, two for each wall, were placed horizontally on the foundations, which before had been carefully leveled.

Between timbers and beams a number of very strong steel rollers were placed in spaces of 80 centimeters (31.5 inches). This work took a fortnight. With the leveling of the foundations, and when the masonry covering of the beams had well set, the last remaining struts could be removed, so that the house, with all its weight of 400,000 kilogrammes (881,840 pounds), rested entirely on the steel rollers, and could be easily pushed along.

In the meantime for all the distance the house had to pass, concrete foundations had been built, which were rendered absolutely level, and were covered with beams and iron plates in such a way that there were four tracks on which the house could be rolled along, as represented in the illustration. These preliminaries accomplished, the proper work of moving the house could begin. For this purpose a thrust-block was fastened to the sliding beams (runners), and between these latter and the house three jacks were placed, which had a pushing capacity of 15,000 kilogrammes (33,079 pounds), and a 40-centimeter (15.7-inch) stroke, and were operated by three men at the same time. This being effected, the house could be moved as far as the stroke of the jacks permitted, viz., 40 centimeters (15.7 inches). After this the jacks were screwed back, and between the thrust-block and the former, the operators inserted beams of the required length, as shown in the illustration of the moving jacks and thrust-blocks. Now the moving could be repeated in the same manner as before, always pushing 40 centimeters (15.7 inches). To secure the house against breakage while moving, all windows were braced and strutted. The inhabitants of the dwelling had all left, but a good deal of furniture still remained.

The owner of the property intends to connect the two houses with a veranda after the moving has been completed, and the villas stand one behind the other.

The cost of moving, repairs and reconstruction is considered to be nearly half as much as taking down and rebuilding the house.

JACKS AND THRUST-BLOCKS WITH WHICH THE HOUSE WAS MOVED

VIEW SHOWING THE FOUR TRACKS LAID ON CONCRETE FOUNDATIONS

MOVING HOUSES IN GERMANY

Tennessee's Resources Told in Pictures

In this day and age, when people write in shorthand they more and more want to read in pictures, unless the matter is one in which they have already become interested. Taking this view of the case, the State Geological Survey has supplemented the bulletins it has been issuing, which are intended primarily to give information when information is wanted or requested, by a little bulletin describing very briefly the resources of the State, but telling the story largely through photographs. This is intended to interest the man who is now not interested, but who may become interested, and through that interest may ultimately move to Tennessee or invest in Tennessee. Nor is this report intended alone for the people outside of the State. Very few Tennesseeans realize the advantages, the wealth, the development or the future possibilities of their own State. If they did, there would be more boosting for Tennessee, there would be less moving to Oklahoma, there would be less need for the "back home" movement, there would be fewer Tennessee capitalists looking to Texas or New York or other places for investment.

The new bulletin is quite comprehensive in its scope, describing not only the various mineral resources, but also the soils, the forests, the topography, climate, transportation facilities, etc., even citing the State's wealth, its debt, tax rate, etc. It not only says that Tennessee is a pleasant place to live, but it shows by selected pictures from the several sections of the State that it is. It not only says the cities are progressive and busy, but it shows by pictures, buildings, homes, parks, business sections, wharves, etc., that the cities are busy, up-to-date and attractive. Attractive pictures of good roads and other country scenes show some of the phases of country life. The forest resources are illustrated by cuts taken from the flank of the Great Smokies to the bottoms of the Mississippi. Tennessee happens to have a number of industrial plants that are the largest of their kind south of the Ohio River. Several of these are pictured in illustrating those industries. Pictures are also given of chert, limestone and marble quarries, of coal, iron and other mines, and iron foundries, copper smelters, etc.

On the whole, one can hardly look through the bulletin, even though he does not have time to read it, without gaining the general idea that Tennessee is a pleasant land, beautiful in its physiographic aspect, a good place to live, rich in many kinds of resources, and that those resources are being developed on a more or less large scale. In addition to showing what already exists there, or is being done, the bulletin especially calls attention to opportunities for further expansion or for further development, either in agricultural development or in exploiting the State's wealth of minerals. It states that many of the mineral resources have hardly yet been scratched, and only awaiting capital to become the source of much profit. It calls attention to the fact that the opening of the Panama Canal is going to prove a gateway to the west coast of both North and South America, and to all of the Orient, and that in the new tide of commerce, which will take advantage of that gate, the South, from its geographic position, has a great advantage over its more northern neighbors. As Tennessee is probably the richest state of the South, both in its mineral and non-mineral resources, Tennessee ought to see a phenomenal growth during the next ten years. But it is first going to be necessary that the people of Tennessee, as well as those outside, realize the opportunities awaiting investment and labor, and take advantage of those opportunities.

While the Geological Survey work will consist primarily in obtaining accurate information about the various resources of the State, and then in supplying that information to those who may request it, it believes that it is also part of its work to call attention to those resources in a way that would interest both people and capital, whether they are now interested or not.

The bulletin has been attractively printed on calendered paper and reflects credit upon the printer, Brandon Printing Company, of Nashville. It can be obtained by applying to the State Geologist, Capitol Annex, Nashville, or upon request accompanied by 2 cents in postage from those outside of Nashville.

New Standard Gage Electric Railroad

The new standard gage railroad which will be opened in Sweden in 1914 presents a considerable interest. It belongs to the State railroad lines, and as we have elsewhere mentioned, runs from the mining district of Kiruna to the frontier. Recently the contract was awarded for part of the electric locomotives to the German Siemens-Schuckert firm, and these are now building at the Berlin works. However, a Swedish company is constructing two high-speed passenger locomotives and two freight locomotives, while eleven freight locomotives will be built in Germany. These last are of the double type and consist of two separate units coupled together. Each unit or half-locomotive has three bar-coupled axles operated from a single electric motor. Transformers on the locomotives are used for lowering the voltage. As each half of the locomotive is independent, this gives a good means of guarding against accidents. The motor is mounted inside the locomotive cabin and drives the wheels by crank drive, so that a large sized motor car be used and there is given better air cooling. The Porjus Falls will be called upon to furnish the current for the electric railroad, and at present the construction work upon the hydaulic plant is being carried out.

Giant Gas Engines and Blowing Tubs

TWELVE-CAR TRAIN LOADED WITH A SINGLE BLOWING UNIT

THE beginning of the twentieth century has seen many advances in the methods and machinery employed in the manufacture of steel. One of the most notable changes has been the introduction of the large gas engine designed to operate on the waste gases from blast furnaces and used to drive the electrical generators which furnish power for driving the machinery about the plant. Another application to which the gas engine has been put is to drive the air compressors which furnish the blast to the furnaces. At the same time a new machine has been introduced to take the place of the older steam driven blowing engine. This is the Slick blowing tub. The first large installation of this type of blowing units was erected at the Homestead Works of the Carnegie Steel Company, where the makers, Allis-Chalmers Company, installed four 42-inch × 54-inch twin tandem gas engines driving 72-inch Slick tubs. When the big power house of the Indiana Steel Company at Gary was built, eight of these units were installed in that. Since then similar units have been installed in the South Chicago plant of the Illinois Steel Company, in the Algoma plant of the Lake Superior Iron and Steel Company, and others larger than any yet installed are now building for the central furnaces of the American Steel and Wire Company at Cleveland.

The design of the Slick tub makes possible the delivery of a much larger quantity of air from a smaller piece of apparatus than was possible with the older type of blowing engine. Two Slick tubs are all that are necessary for the largest furnace, while three or four of other types would be necessary.

The essential difference between the Slick blowing engine, or tub, as it is commonly called, and other blowing engines, lies in the method of admitting air to the compressing cylinder. In other types large valve area is required which necessitates either large valves or numerous small valves. In the Slick design the entire cylinder of the compressor serves as the valve. The inlet ports, in this design, are located in the barrel of the tub and consist of a series of circular openings extending entirely around the circumference of the barrel at each end. The barrel is not attached to the heads, but is supported and moves on independent slides at each side. Connection is made to the engine on each side, and the barrel is given a reciprocating motion while the heads remain stationary. This construction gives great inlet area for a very small motion of the barrel and leaves the entire area of the heads free for the discharge valves.

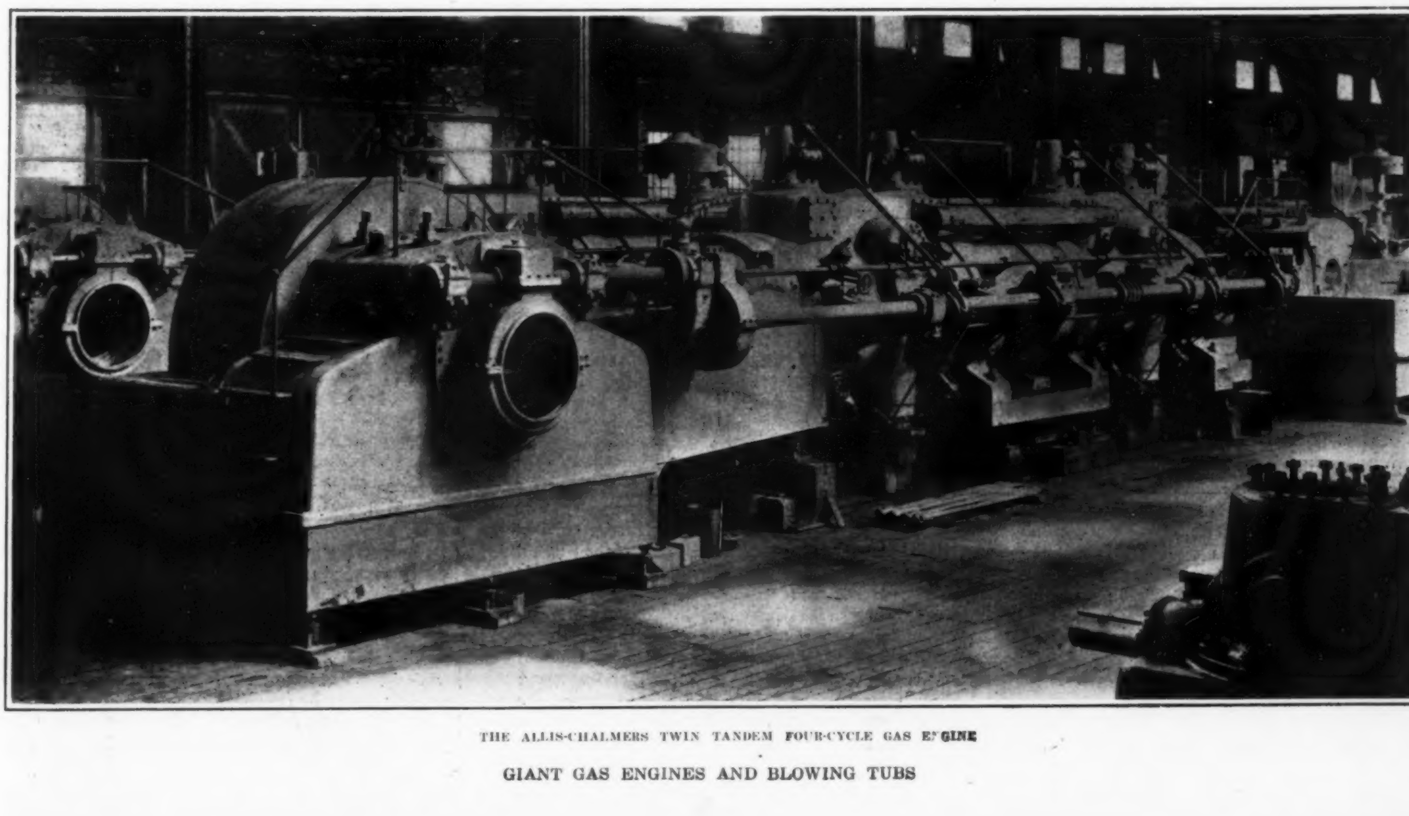
The advantage of this construction is that the air completely fills the tubs with practically no drop below the atmospheric pressure at the beginning of the suction stroke. The large discharge valve area of the heads greatly reduces the clearance necessary in the cylinder and also prevents the air pressure in the cylinder rising much above the pressure in the receiver. The small movement of the valves and the large port openings permit of much higher piston speeds than can be used with other types of blowing engines, and consequently the use of smaller machines for the same amount of air.

These Slick blowing tubs are used with both steam engines and gas engines, more frequently with the latter, however, as they were developed about the same time that the large gas engine came into use in the steel industry. The usual practice is to place the steam or gas cylinders at one end of the frame while the tub is fastened to the other. This gives a short and direct drive for the barrel from the engine shaft while the air piston is connected to the cross head by means of distance rods, and has the same travel as the gas piston. This gives a very rigid and compact machine.

The gas engine which Allis-Chalmers Company build to go with these blowing tubs embodies the most modern developments which experience has proved advisible, with the result that its design differs somewhat from European models in order to meet American conditions. Progress in the design of large gas engines has been much influenced by natural conditions existing in the steel industry which presented an ideal field for their use in the utilization of waste gases. The conditions demanded an engine which would operate on a gas of low heat value and which was reliable for continuous and severe service.

The Allis-Chalmers gas engine is of the horizontal, double acting, four-stroke-cycle type with the gas cylinders arranged in tandem. This arrangement applies power to the common piston rod at each forward and backward stroke and gives the same continuous application of power to the crank shaft that is obtained with the simple steam engine. When twin engines are used, as with the blowing tubs, four power strokes are obtained per revolution. These, with the use of a properly designed fly wheel, give a very even turning moment.

It is in the frame that the principal difference in design is apparent. Foreign practice favors the use of the center crank which necessitates three bearings for a single engine and four bearings for a twin engine. The Allis-Chalmers engine requires but two bearings for either single or twin engine. Another essential feature of this engine is the use of an intermediate cross head between the two cylinders and a tail cross head behind the second cylinder. These support the pistons and piston rods so that they can travel without touching either the bore of the gas cylinders or stuffing boxes. This design also places the inlet valves at the top of the cylinders and the exhaust valves at the bottom, which is essential to the proper scavenging of the cylinder. Provision is also made for removing the cylinder heads without disconnecting the cylinders from the main frame or tie pieces. These gas engines give the impression of solidity and simplicity and show great strength. Their quiet running and freedom from vibration are



THE ALLIS-CHALMERS TWIN TANDEM FOUR-CYCLE GAS ENGINE

GIANT GAS ENGINES AND BLOWING TUBS

particularly apparent. This is true with overloads as well as underloads, and there is in fact no noticeable change in the operation under wide variation in loads.

As the point of greatest stress in a gas engine is in the frame, the weight of the frame of this engine is made about one-fourth the total weight. The jaw in which the main bearing shells are held, and which is subject to the greatest stresses, is made particularly heavy and rigid. It is further strengthened by two steel tie bolts extending across the jaw above the shaft, which eliminate all bending stresses in the frame at this point, but do not interfere with the removal of the main bearing cap.

The cylinders are cast in one piece, and a tough fibrous iron is used which is well adapted to meet the strains encountered. The outer cylinder walls with the tie piece form a continuous frame work and provide a very rigid construction. The inner wall of the cylinder is subjected to the explosive pressure only. Gas and air inlet passages and a distribution chamber are cast integral with the cylinder.

To provide a wearing surface, the cylinder is fitted with a liner of a special grade of very hard, fine grained iron which has particularly good wearing qualities and which readily takes a high polish and thereby reduces friction. A special patented construction of a tongue and groove fit at the middle of its length, together with a shrink fit over its entire length holds the liner firmly in place while permitting free expansion with the cylinder walls.

The valve gear is of the stratification type which permits control of the engine by varying the relative proportion of air and gas. The valve is double seated with the air admission between the two seats and the gas admission above the upper. The relative amounts of air and gas are controlled by an auxiliary lay shaft actuated by the governor. The two inlet valves for each cylinder are located at the top and the two exhaust valves at the bottom so that all impurities leave the cylinder in the most natural way. The exhaust valves and all the parts of the engine coming in contact with the hot gases of explosion are water cooled.

These engines are started by means of compressed air and an auxiliary starting gear which is automatically cut out when the engine is ready to operate on gas. The method of starting is very simple, and the time occupied is inappreciable. In one of the large power houses where these engines are used to drive alternators it is usually less than one minute from the time an order is given to start the engine to the time it is put in service and delivering load. The record time is 37 seconds.

One of the accompanying photographs shows a train loaded with a single Allis-Chalmers gas engine blowing unit. The apparatus loaded on the train contains the parts of a twin tandem gas engine and the Slick blowing tubs for the unit. The first two cars are loaded with the main engine frames weighing approximately 180,000 pounds each, the third car supports the main shaft and cranks, the next four cars each carry a gas engine cylinder, the next two each hold a tie piece and tail piece for one gas engine, while each of the last two cars is loaded with a Slick cylinder and some of the accessory apparatus. Many of the detail parts are not shown in this photo.

During the past few months the Allis-Chalmers Company has shipped four gas engine generating sets and two gas engine blowing units to the Lake Superior Iron and Steel Corporation at Sault Ste. Marie, Canada, and has two more of the blowing units nearing completion. Each one of these units required twelve cars for its transportation, and its weight approximated 1,000,000 pounds.

These gas engine units are being installed in a large extension of the Lake Superior Iron and Steel Corporations' plant at Sault Ste. Marie, Ontario, Canada. The original rail mill will have a largely increased capacity, and new plate and merchant mills will be built as well as coke ovens. Operations will be started at the plant in the near future. For furnishing power for the mills and blowing the furnaces the company purchased the above units from Allis-Chalmers Company. They will be supplied with gas from the blast furnaces.

The gas engines are all alike, being of the twin tandem four-cycle type with cylinder 34 × 48 inches. They conform to the company's standard in all respects. Four of these engines are direct connected to 1,765 K. V. A., 25-cycle, 3-phase, 2,300-volt alternators running at 107 R. P. M. These sets will supply power for driving the motors about the mill.

The other four units are to be connected to the new Slick blowing tubs manufactured by Allis-Chalmers Company. These tubs are 64 × 48 inches, and are arranged to operate duplex on the opposite side of the main shaft from the engine. Each blowing unit has a capacity of 25,000 cubic feet per minute when running at 72 R. P. M., but can be speeded up to 85 R. P. M. if necessary.

When the new works are completed this will be the largest steel producing plant in Canada, and naturally the most modern. Mr. Alfred Ernst has been consulting engineer on the work, and much of its success will be due to his efforts.

Heating and Ventilating the Yarrow Home

A Series of Interesting Experiments

The question of providing the best system of ventilation and heating for public buildings and especially for Hospitals and Convalescent Homes, is of so much importance that the following experiments cannot fail to be of interest.

On the occasion of the annual gathering at the Yarrow Home on July 17th, 1909, certain changes which had recently been made in the heating and ventilation of the Institution were described by Mr. Yarrow.

The system of heating and ventilation was carried out in a very complete manner when the Home was constructed, and was based upon the best knowledge available at the time, but experience has indicated that in many essential particulars the system adopted was far from satisfactory, and it became evident that changes must be made.

The heating was secured by means of numerous radiators in the usual manner, fresh air from outside being admitted through openings at the back of the radiators, thus coming in direct contact with the hot surfaces and getting warmed on its passage into the building. This, at first sight, appears correct, but a little consideration shows it is open to objections. What really happens is that the radiators very soon get covered with dust brought by the incoming air, and this dust, as is well known, brings with it numerous microbes. Often these radiators are fixed in such a position that it is impossible to clean them efficiently. Sometimes they are in recesses to be out of the way; at other times the design of the radiators is such that it is impossible to get brushes between the heating tubes. On some systems the heating is done by means of hot pipes under the floor with gratings above them, and on others the radiators are inclosed in ornamental cases for the sake of appearance. In most cases it is found that the radiators are of such a design, or so placed, that it is impossible to secure the cleanliness and freedom from deposit of dust so essential to good sanitary conditions.

Mr. Yarrow pointed out that the conviction was forced upon everyone who had studied the subject that the only form of really good radiator is one of such design and so placed that it can be cleaned and dusted daily with facility. Probably, to carry this out in the best manner, the radiators should consist of polished tubes, because, being bright, any deposit of dust is made visible, and in addition, servants naturally, if they take a pride in their work, see that any polished surface is kept in a creditable condition.

Having these considerations in view, the inlets, which previously conducted the fresh air into direct contact with the radiators, were permanently closed, so that now the air has not the opportunity of depositing its dust upon the heated surface of the radiators or of carrying into the rooms the already accumulated microbes.

Mr. Yarrow then described the system of ventilation originally adopted, which consisted of horizontal air ducs along the ceilings of the rooms. These air ducts terminated at each end of the building in tall ventilating shafts. The tendency for the hot air to pass out in this way is due to the difference in weight of the hot air inside the shaft and the cold air outside the building, just in the same way that a chimney over a fire allows the hot products of combustion to pass upwards. In such ventilating systems, however, the difference of temperature and consequent weight of the air is so very small that the draught is necessarily sluggish, consequently, to reverse the direction of the current of air requires very little counteracting influence.

Mr. John Sampson, a member of the Committee of Management of the Home, drew attention to the effect which wind had on ventilation, and demonstrated in the clearest possible way that wind striking the building on one side had a tendency to increase the pressure of air in the rooms on that side, and at the same time to diminish the air pressure in the rooms on the opposite side. Now, in those rooms where the pressure was diminished, the reduced pressure had clearly a tendency to upset the system of ventilation, causing the passages which were intended as upcasts to be downcasts.

Numerous experiments were tried in all the rooms, not only when there was no wind, but when the wind blew on the building from different quarters. It was found that when there was no wind the ventilation acted perfectly and as was intended, but the moment a slight wind arose, which at Broadstairs is of general occurrence, it was found that in many of the rooms the air, instead of passing away through the ventilating passages and up the shafts, was actually drawn down owing to the suction due to the reduced air pressure in those rooms on the sides of the building opposite to those upon which the wind blew. Now, it is self-evident that if the air enters the building after having passed through passages, which from their nature can never be cleaned, and which are charged largely with dust, full of objectionable organisms, and which were never intended for admitting air, but for letting it out, the result must be most unsatisfactory, and there appeared to be a reasonable probability that many sore throats had been due to this cause.

The committee being firmly convinced from the above considerations that the system of ventilation had been founded on wrong principles, ordered all the openings in the ceilings of the rooms leading to the ventilating passages to be closed. They had the beds removed from the sides of the dormitories and placed in the center, and gave instructions for the windows to be always slightly open, so that the ventilation of each dormitory should depend entirely upon the passage of air across the rooms entering the side where the wind blew, and finding exit on the opposite side. As there scarcely ever exists a time when there is not more or less breeze, it would appear that this was both a simple and efficient means of continually changing the air.

As the result of this investigation, it would appear that one of the secrets of ventilation is to prevent air passing through any passages where dust and dirt can accumulate; in fact, the air prior to entering the rooms should pass over the minimum surface.

A doll's house was used in order to illustrate by actual experiment what occurred when a current of air blew on one side of the home. A fire was lighted in a room in the doll's house, and the smoke ascended and was seen issuing from the chimney. A rotary fan, actuated by an electric motor, produced a current of air corresponding to a moderate wind—that is to say from 12 to 15 miles and hour—which was allowed to impinge on one side of the doll's house, and it was at once seen, when the window was open in the doll's house on the side opposite to that on which the air impinged, that smoke was immediately drawn down the chimney instead of passing upwards, owing to the reduction of pressure on the side opposite to that on which the current of air was blown.

The following description was given by Dr. Dawson:

The bacteriological examination of the air not only confirmed the opinion that, under certain conditions, what are intended for ventilating outlets became inlets, but also showed the vitiation of the air in Ward No. 1 which resulted.

Two prepared plates were exposed beneath the air-shaft in the ceiling of the ward. These plates were, so to speak, "back to back;" that is, the medium on the one looked upward toward the opening in the ceiling, and the medium on the other looked downward toward the floor. Plates were exposed actually within the air shafts. Others were also placed on the beds in the ward, and finally a plate was placed midway between the floor and ceiling underneath the air shaft. All these plates were exposed for a period of five minutes. The results were as follows:

The plates within the air shaft, and the plate immediately beneath it showed a rich growth of micro-organisms, whereas the plate under the air shaft, whose medium looked downward, was comparatively free. The plates also placed upon the beds in the ward contained only a few colonies.

Further than this, among the rich crops of micro-organisms found on the plates near the air shaft were many pathogenic varieties; and especially noticeable among these were the *Micrococcus Caturrhalis* and *Staphylococci*, which are so often associated with sore throats, whereas in the plates remote from the air shaft the pathogenic organisms were *exceedingly* few. The fact that the plate near the air shaft which looked upward was richly covered with organisms—whereas the plate immediately beneath it which looked downward showed very few—shows that the air was traveling *into* the room and not *out* of the room through the so-called outlet. This conclusion was further confirmed by the plates inside the shaft con-

taining the same varieties of organisms as the plate immediately beneath the grating.

In Ward No. 2 very similar in size and shape, a control experiment was conducted, the air shaft in the ceiling being blocked up, and plates being exposed in the same position as in Ward No. 1. The plates in every instance showed but a feeble growth of microorganisms; one of the plates showing only 17 colonies as against 89 colonies found on the similar plate correspondingly situated in Ward No. 1. It is clear, therefore, that the air was a great deal purer when the ventilating outlet in the ceiling was blocked up.

Now, the Yarrow Home has been troubled for some time past with small epidemics of sore throats, and it has been in some instances established that the sore throats do not spread from person to person, but would break out in different wards where the inmates have not been in contact.

These troubles entirely ceased when the ventilating shafts in the ceilings were closed. The fact is that the ventilating shafts which lead from the ceilings of the wards to the outer air are in close juxtaposition. As long as there is no wind, it is probable that these shafts would operate as outlets, as they were originally intended to do; but directly there is a wind these outlets become inlets, and impure air enters the wards, and the air of one ward can communicate with the other.

This investigation also shows once more that all air shafts are dangerous unless they are so big and so situated that they can be easily and regularly flushed with water. Unless this is the case the air shafts collect more and more dust, and the air which passes along them becomes increasingly dust-laden, and therefore microbe laden. The wards have been far more healthy at the Yarrow Home since these air shafts were blocked up and the windows and chimneys have been relied upon for ventilation.

The examination of the air was made at the suggestion and under the supervision of Dr. Dawson, assisted by Dr. Moon. The bacteriological experiments were carried out by Dr. Adler.

On November 1st, six months after the above changes in the heating and ventilation had been made, Miss Chambers, the lady superintendent of the home, reported as follows:

"We have found a very appreciable reduction in the number of sore throats during the past six months, and, of the few cases we have had, all have been children with adenoids and enlarged tonsils, or who suffer from repeated sore throat affections at home. We have had a case of measles, and two of chicken pox during the last six months, but no spread of infection from either as formerly experienced."

The Bee as an Engineer

The Structure of a Piece of Honeycomb

By A. H. Godard

HONEY bees have always been a subject of great interest for the naturalist, and one of the most interesting features of their work is the home and storehouse which they build for themselves (Fig. 1).

Nearly everybody has seen a piece of honey comb, but probably few realize how perfect a piece of architecture it is for the purpose intended. It is perfect because it combines these three qualities: *it has no waste room; it has the greatest possible strength; and it is constructed out of the least possible material.*

If we look at the face of a piece of comb, we observe that the cells are six sided. Did you ever stop to think why? The answer is, because that is the only shape that will fulfill the above conditions. Let us see. In the first place there are only three forms of cells that can be placed side by side without leaving waste spaces between (see Figs. 1, 2, 3, 4, 5). There are the triangle, the square and the hexagon. Secondly, the more nearly round a hollow object is, the more pressure will be required to crush it, a fact well known to every one, and thirdly, the more round it is, the less material will it take to complete its peripheral wall. One might almost imagine that these last two facts are recognized by the bees themselves, for in the case of a special cell that they construct for their queen, where there is only a single cell built up on the edge, this cell is always round and not hexagonal. But to prove the third proposition, the economy of material, let us look at Fig. 6, which represents four different forms with an area of uniformly 144 square inches. The triangle will be about 18¼ inches on a side and 54¾ around. The square will be 12 inches, and 48 inches around. The hexagon will be about 7½ inches on a side and 45 around, while the circle, which we have said we cannot use, would be only 42½ inches around. So again we find the hexagon requiring less material than the other forms, and thus fulfilling all three of the conditions named.

But this is not all. If this point were made too long or too short, then again there would be waste of material as well as strength. There must be a certain specific correct length. Let us look once more

The writer has seen strips of comb a foot wide and four feet long, sustaining a weight of thirty or forty pounds of honey, while the comb itself would probably not weight more than five or six ounces. We

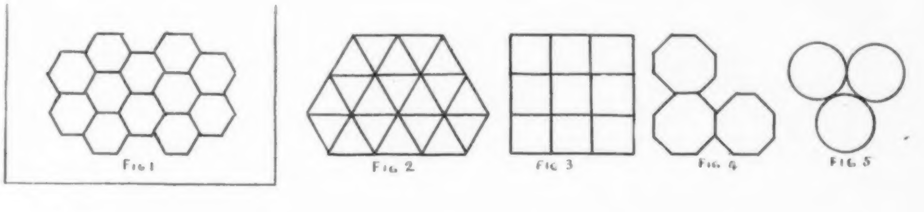


Fig 1 Fig 2 Fig 3 Fig 4 Fig 5

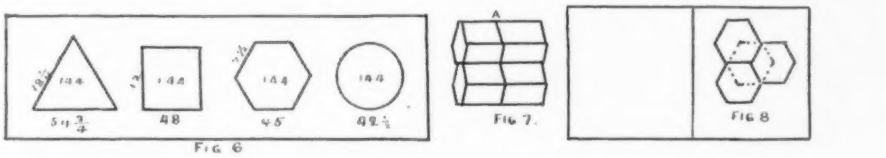


Fig 6 Fig 7 Fig 8

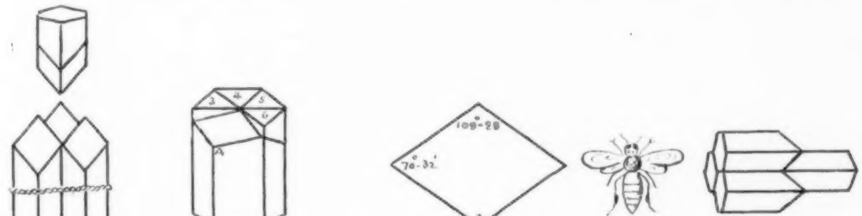


Fig 10 Fig 11 Fig 12 Fig 9

So much for the sides. Now let us look at the bottom of the cell. Usually a piece of comb is about an inch in thickness, but you will notice the cells only run half way through, that there is a partition in the center which forms a bottom for the cells on both sides of the comb (see *A*, Fig. 7). Now these cells from opposite sides do not meet haphazard, but if you will look into an empty cell (see dotted line cell, Fig. 8), you will notice that what is the center of the cell on one side coincides with the point where three cells come together on the opposite side. Again the bottom of the cells are not flat like the bottom of a tumbler as represented by Fig. 7, for in that case there would be the square corner and the same waste of material as in the square cell, but each cell is carried out to a point past the center of the comb (Fig. 9).

The question then arises, how can this be done so as to have opposite cells match? This can best be understood by a simple illustration. Cut off from a common six-sided lead pencil four pieces an inch or more long, sharpen them exactly alike, bluntly, cutting only from the flat sides, then tie three of them together to represent one side of the comb and try to fit the fourth piece, and you will find that they will not match. So we must try again. Now sharpen your pencils once more, this time by cutting the corners, instead of the flat side, and be sure you cut only every other corner. This will give you three surfaces instead of six. Now tie together again and you will find a perfect fit (see Fig. 10).

Now if you should look into a cell you would see three flat surfaces running to a point, as represented by the dotted line cell (Fig. 8).

into the cell and we find the three end surfaces are rhomb shaped like Fig. 12, with two obtuse and two acute angles (see obtuse angle at *A*, Fig. 11), and it is evident that as the point of the cell is moved in or out this and the other angles will change, the farther the point the more nearly square the rhomb will become, and of course the less the obtuse angle will be. Many years ago a naturalist requested a celebrated mathematician to solve this problem, "What should be the angles of the facets of a three sided pyramid terminating a six-sided prism, so as to combine the greatest strength with the least material." You will notice that this is the problem before us. His answer was 109 degrees 26 minutes for the obtuse and 70 degrees 34 minutes for the acute—values falling within one-thirtieth of a degree of what the comb actually measures, the exact measurement being 109 degrees 28 minutes and 70 degrees 32 minutes. Notice how this piece of bridge work in the center of the comb stiffens and braces the structure.

So far, the material for the comb is supplied by the bees from their own bodies, issuing from the overlapping joints or rings seen on any working bee. But there is still one place of the comb that is a little weak, namely, the mouth of the cell. This weakness is remedied by the use of a substance which the bees gather from the barks of trees, and which has been called "propolis," a Greek word meaning "before the city." This material is of a much harder and firmer nature than the comb itself. If you take a piece of white comb and tip it so that you can just glance across the surface, you will discover the presence of the propolis by its brown color.

need not hesitate to say that such a structure compares favorably with some of the best achievements of the modern engineering skill of man.

A New Variety of Selenium

F. C. BROWN has discovered a new variety of selenium in which the electric resistance is increased, instead of being diminished, by exposure to light. Its specific conductivity is one million times greater than that of ordinary selenium. Thirty experiments were required to produce five specimens of the new form of selenium, which is very unstable during the process of formation. In every case the selenium was crystalized in molds of enameled porcelain. Two German silver wires, about ⅛-inch apart, served as electrodes. The resistances of the five specimens, each measured in the dark two hours after its removal from the crystallization oven, heated to 285 deg. F., differed very greatly, the values expressed in ohms being, 1.3, 12, 117, 164 and 187. The surface of the silenium was smooth and reddish-gray at first, but the tint afterwards became redder and darker. The resistance of one specimen rose from 117 to 118.5 ohms in 10 seconds' exposure to the light of a 16-candlepower carbon filament electric lamp at a distance of four inches. The return to the initial resistance appears to take place as rapidly and completely as it does in ordinary selenium cells. Several years ago Brown advanced the theory that ordinary selenium is a mixture of two or more allotropic forms. He regards the new variety of selenium as a mixture of the same ingredients in different proportions.

Diesel Marine Engines—II*

A Resume of Recent Performances

By Herr Th. Saeuberlich of Osterholz-Scharmbach

Continued from Supplement No. 1846, page 318

The reversing gear of this engine differs from other known designs. The principle employed is to move the valve shaft, on which two separate sets of cams are fashioned, endwise; the valve levers being raised by cams just before this movement takes place and lowered again when it is complete. These movements are effected in the following very simple way and by the use of a single hand wheel:

The shaft *a*—Fig. 8—passes over all the cylinder covers, being carried by the columns *b*, of which there are two in each cover. To this shaft are keyed the fingers *c*, one over each exhaust and suction valve, and the lever *d*, which is linked by *e* to the curved lever *f*, *f* in turn being coupled to the reversing cylinder, which has pipe connection *g* and *h* coupled to the valve box beneath the hand wheel. Here either valve can be released by movement of the ⊥ lever *l*, which is effected by one end or other of the notched quadrant *n* coming into contact with it, this quadrant being keyed to the hand-wheel shaft. The valve being opened further movement of the plate releases the lever, and the valve again closes. Owing to the form of the quadrant *n* and the notches in the quadrant *p*, this movement can only be effected in the central position II. In Fig. 10 is seen a sector *T*, which is provided with a cam face which moves the lever *B*, and thus moves the reversing cam shaft *N* endways. The sector is coupled by the link shown to the shaft *w*. The action of the reversing gear will now be easily understood. The hand wheel is moved to the middle position and is then revolved till the stop *r* on the notched quadrant comes against the quadrant *p* and stops further movement. During this action the valve *i* would be opened for a short time, allowing compressed air to get under the piston *k*, forcing it up. This causes movement of the linkage, and presses the valves down into the cylinder. When they have reached their lowest position the action of the cam *T* moves the cam shaft endways. By that time the piston *k* has returned to its starting position, lowering the valve rockers on to the second set of cams. The glycerine dashpot acts as a brake to prevent reversal taking place too violently. It must be added that during this process the rollers of the starting and fuel valves are lifted off their cams, and do not interfere with the motion. This is effected as seen in Fig. 7 by mounting the respective rockers on eccentrics keyed to the shaft *w*. By turning the sleeve the fuel valve lever moves away from its cam, while the starting valve lever approaches its own cam. In this position both levers are free, and the shaft can be moved endways. By further movement to the starting position, the fuel valve lever leaves its cam, while the starting valve lever comes into actual contact with its own. Rotation is given to the eccentric sleeve in the manner shown in Fig. 9, from which it will be seen that it is coupled by the rod *L* to the shaft *M*, to which is also keyed the hand wheel bracket *H*. This bracket with the hand wheel can be moved to three principal positions on the notched quadrant *p*—the first for running, the second neutral, and the third or lowest for starting. Further notches for half and slow speed are also provided. This control is effected by the link *d*, which acts upon the fuel pump regulator rod. As the centrifugal governor shown also acts upon this rod, an elastic coupling in the form of a flat spring *F* is provided. The governor was originally provided for the test stand, but in view of the fact that the engine might run light has been retained.

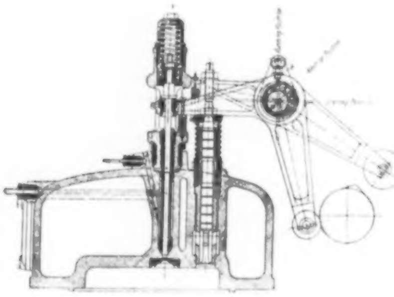


FIG. 7.—AIR AND OIL VALVES AND GEAR

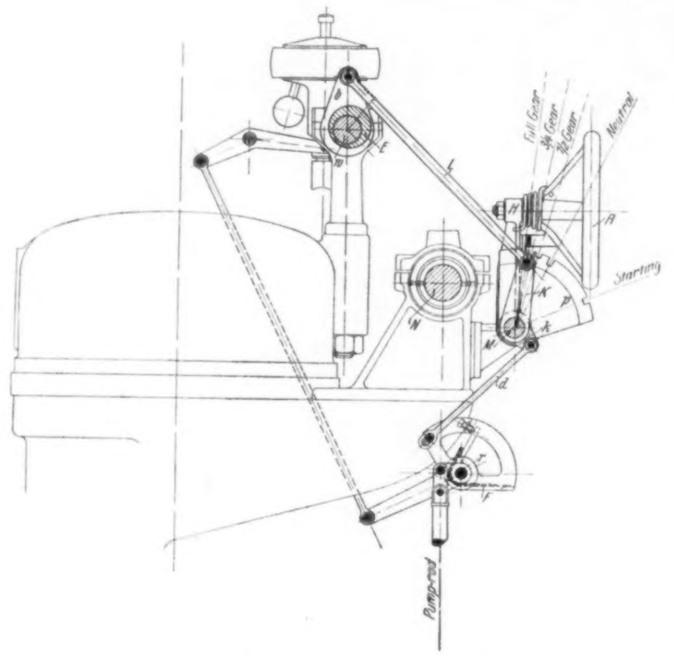


FIG. 9.—CAM LIFTING AND GOVERNING GEAR

It has already been pointed out that in a four-cycle engine all four cylinders might be in such a position as to render starting by compressed air in the cylinders impossible, and that therefore arrangements had been made to use the air compressor for starting under such conditions. This air pump is shown in section by Fig. 11. It is a two-stage compressor with the low-pressure stage double acting and without suction valves, air being admitted by the piston overrunning a central port. On this low-pressure cylinder are placed the starting valves *A* and *B*, operated by the cams and links shown. The compressor being double acting, it is easy to arrange that it shall start in any position which it is not possible for the power cylinders to start from. Diagrams from the compressor are given in Figs. 12 and 13, and enlarged views of the valves in Fig. 18. The fuel pump is illustrated by Fig. 17. There is one plunger to each main cylinder, but the plungers are coupled in pairs so that only two eccentrics are required. The governor already described acts, as shown in Fig. 17, upon the suction valves. The pump body is a single piece of wrought iron.

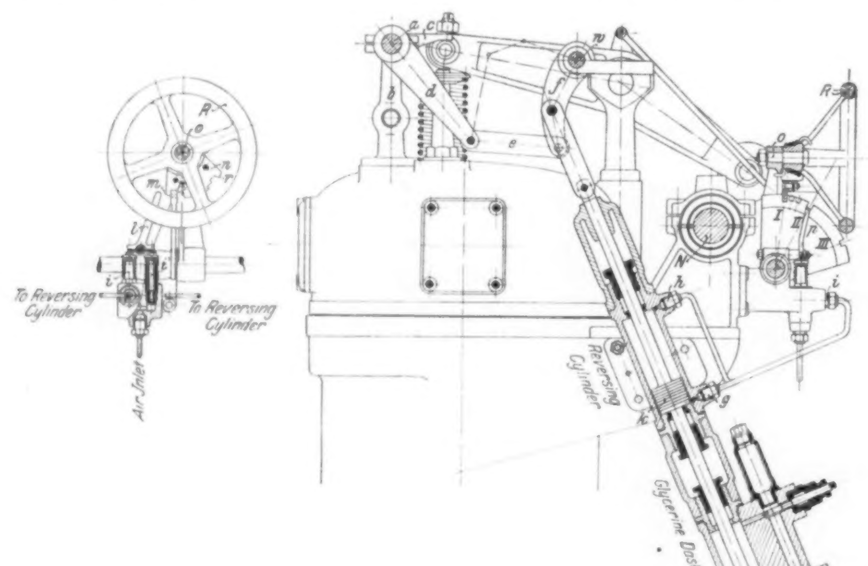


FIG. 8.—REVERSING GEAR

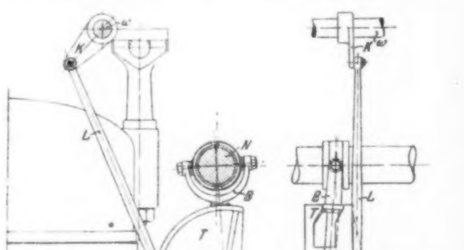


FIG. 10.—CAM SHAFT GEAR

* Abstract translation by *The Engineer* (London) from a paper read before the Schiffbautechnischen Gesellschaft and published in the *Journal* of the Society by Julius Springer, Berlin.

The method of constructing the valve cams is shown in Fig. 15. The exhaust and suction cams are of cast steel, and the starting cam of cast iron. By this method a small diameter of cam results, and quietness of running is secured.

The lubrication of the gudgeon pin, which is always a troublesome matter, is effected in this engine by the device shown in Fig. 14. Here the tube *A* on the piston at each outward stroke is driven into oil contained in the cup shown, some oil enters the tube, and being retained by the little ball valve, is driven up by the next descent of the tube.

The method of driving the cam shaft is illustrated by Fig. 16. It will be seen that the arrangement permits endways movement of the shaft, while the long bush acts also as a thrust block.

It is not generally possible to obtain such good diagrams from high-speed as from slow-speed engines, owing to the very short space of time in which explosion has to take place, but almost ideal cards, as shown in Fig. 19, are obtained from this engine. The average pressure shown by this diagram is about eight atmospheres. The fuel consumption measured on the test bench amounted to between 215 and 220 grammes per effective horse-power per hour.

Practical Results.—The service boat in which the engine just described is fitted has been for a long

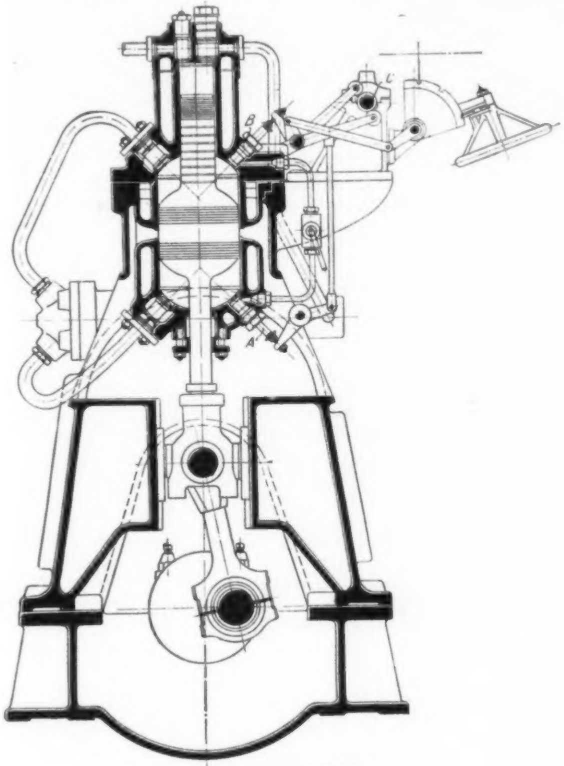
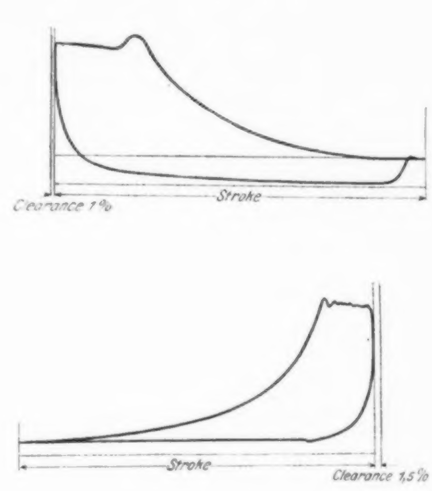


Fig. 11.—AIR COMPRESSOR



Figs. 12 and 13.—COMPRESSOR CARDS

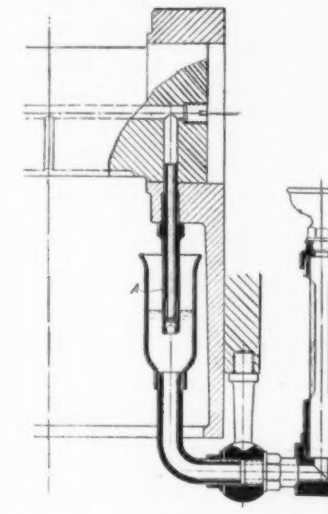


Fig. 14.—GUDGEON LUBRICATOR

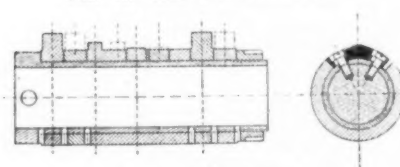


Fig. 15.—VALVE CAM

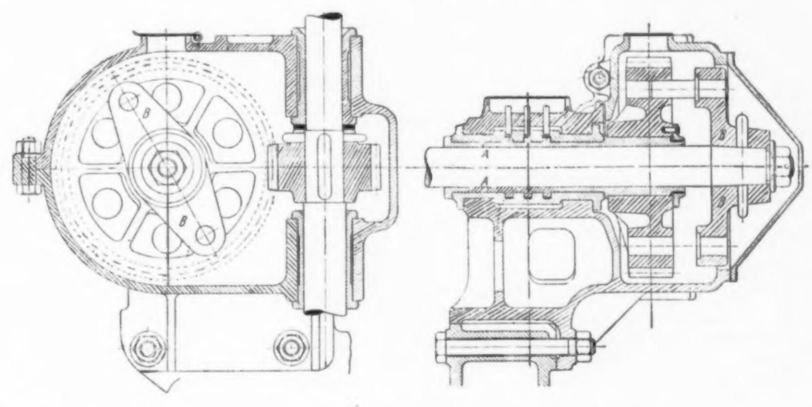


Fig. 16.—CAM SHAFT DRIVING GEAR

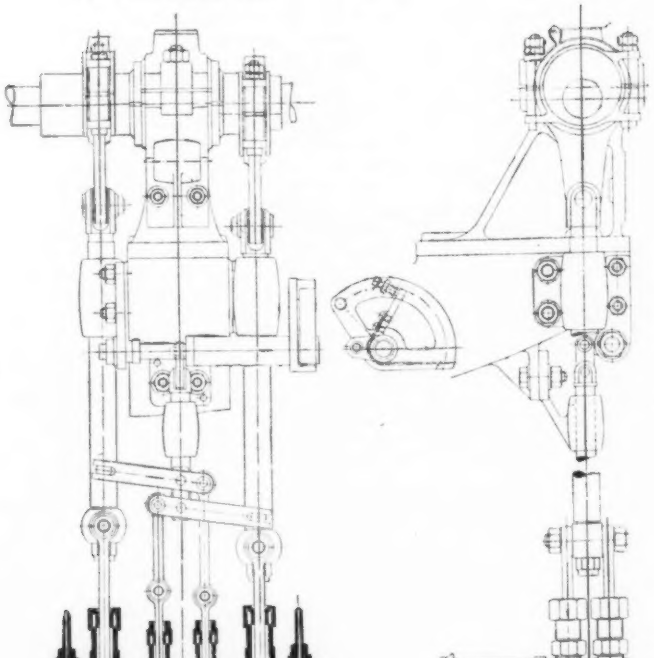


Fig. 17.—FUEL PUMP

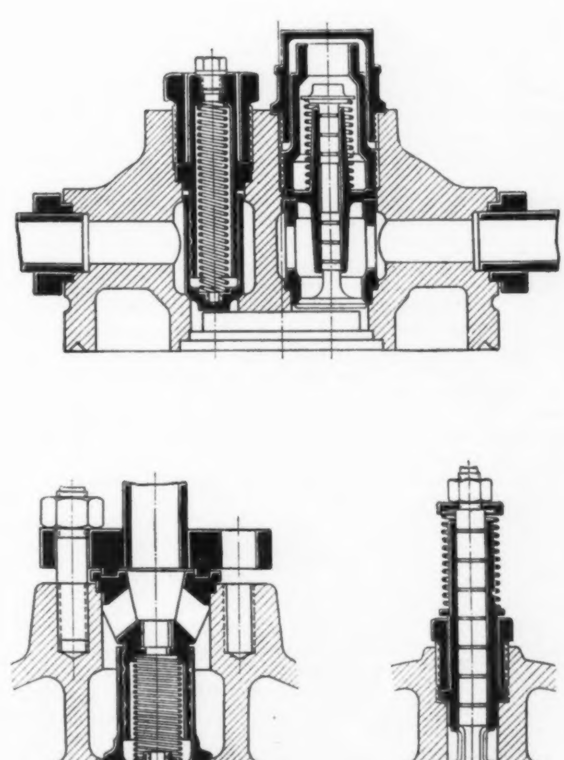


Fig. 18.—COMPRESSOR VALVES

time in regular work, and with regard to handiness fully answers all the expectations formed of her. The insurance companies have made exhaustive tests in this respect with a view to fixing the premiums payable, and have satisfied themselves that the maneuvering capacity is equivalent to that of a steamship, and they have therefore made the premium the same as that customary for steamships. The maximum speed of the boat can be reduced, by regulating the motor, from about 10 miles to about 3.8 miles per hour; the revolutions of the motor being lowered from 360 per minute to about 150 per minute. The lowest attainable number of revolutions is normally about 40 per cent of the maximum. The effective horse-power in this case is reduced from about 200 to 35. The speed governing of the motor can be effected either by cutting out a cylinder, releasing at the same time the fuel pump of the cylinder in question, or by regulating the supply of fuel to all the cylinders. Reversing is carried out with surprising speed and safety. Tests carried out in comparison with similar ships with steam engines have given the following results:

Table I.

	A.[1]	B.[2]
	Steam Tug.	Motor Tug "Frerichs."
	Seconds.	Seconds.
1. Engine starts from rest, ahead about...	4.5	2.5
Engine starts from rest, astern about...	4.5	2.5
Engine reverses, from beginning of motion, full forward to full astern	15	8
2. Beginning of ship's motion forward from rest	6	11
Beginning of ship's motion astern..	10	12
I. Ship comes to rest from full forward to full backward	30	27
II. From rest to full speed astern	20	10

[1] L., 20.95 m.; br., 4.86 m.; d., 2.18 m.; I. H. P., about 180; revs., about 185; reversing hand-wheel.

[2] L., 18 m; br., 4.9 m.; d., 2 m.; I. H. P., about 185; revs., about 300; reversing hand-wheel.

Thirty maneuvers can be carried out per hour without alteration of the air pressure in the starting tanks, while with the quantity of air stored in the starting tanks 60 consecutive maneuvers can be carried out. The starting tank holds 250 liters, and when quite exhausted it can be repumped to full pressure in 15 minutes.

(To be concluded.)

Radioactivity as a Kinetic Theory of a Fourth State of Matter[*]

There are many points of resemblance between the movements of the molecules of a gas and the movements of those corpuscular radiations with which we have become acquainted in following up the discovery of radioactivity. In both cases we find that things of extremely minute dimensions are darting to and fro with great velocity, and in both cases the path of any one individual is made up of straight portions of various lengths, along which it is moving uniformly and free from external influence, and of encounters of short duration with other individuals, when energy is exchanged and directions of motion are altered. There is even a resemblance in the universality of each movement. The motion of molecules is a fundamental fact throughout the whole of our atmosphere, and, indeed, in all material bodies; the motion of the radiant particles emitted by radioactive substances is also widely distributed, and of great importance. Taking Eve's estimate of the usual ionization of the air, we can calculate that in this room, in every second, some thousands of α and β particles enter into existence, complete their paths through all the atoms they meet, and sink into obscurity; some of them, viz., the α particles, as atoms of helium. These last move through definite and well-known distances in the air. For example, a third of those which are due to radium products move through a range of just above 4 centimeters, an equal number have a range of just below 5 centimeters, and again an equal number move through 7 centimeters, and the speed is so great that the life of each α particle as such is completed in about a thousand-millionth of a second. They leave their mark behind them in the ionization of the air through which they have passed, and in the heat into which their energy has been commuted. The former effect is easily detected by the sensitive measuring instruments which we now possess; the latter is too small to measure, and must be greatly increased by the aid of radium itself before it can be investigated. But on a large scale, which takes into account the distribution of radioactive material through the earth, the sea, and the air, the effects are of first-rate importance to the physical conditions of our earth.

If we compare the movements a little more closely, we find differences as interesting as the resemblances. The motions which the kinetic theory of gases considers are those of the molecules of which gases consist; in the case of radioactivity, the things which move are quite different. They are sometimes electrons, which have come to be called β rays when their speed is great, and kathode rays when it is somewhat less; or they are γ or X-rays, which are new things to us; or if as α particles they are helium atoms, such as we have known before, they move with excessive speeds which give them quite new properties. In general, the radiant particles move hundreds of thousands of times as fast as the gas molecules do, and it is, no doubt, on account of this fact, as well as through their usually extreme minuteness, that their power of penetrating matter is so great. When two molecules of a gas collide, they approach within a fairly definite distance, which we call the sum of the radii of the molecules, and the approach is followed by a recession and new conditions of motion. Each molecule has, as it were, a domain into which no other molecule can penetrate. But the defences which guard the domain are of no account to the vigorous movements which we are considering now. The radiant particles pass freely through the atoms, and their encounters are rather with one or other of a number of circumscribed and powerful centers of force which exist within the atomic domain, and act with great power when, and only when, approached within distances which are small in comparison with the atomic radius. It is on this account that the new theory opens out to us such possibilities of discovering the arrangement of the interior of the atom. Never before have we been able to pass anything *through* an atom; our spies have always been turned back from the frontier. Now we can at pleasure cause to pass through any atom an α particle, which is an atom of helium, or a β particle, which is an electron, or a γ or X-ray, and see what has happened to the particle when it emerges again, and from the treatment which it seems to have received we must try to find out what it met with inside.

The newer movement exists superimposed upon the other. Its velocities are so great that the gas (or liquid or solid) molecules are, in comparison, perfectly still. There is, as it were, a kinetic theory within a kinetic theory; there is a grosser movement of gas molecules which has long been studied, and in the same place and at the same time there is a far subtler and far more lively movement which is practically independent of the other. Your vice-president, Sir William Crookes, was the first to find any trace of it. The behavior of the kathode rays in the vacuum tubes which he had made showed him that he was dealing with things in no ordinary condition. Whatever was in motion was neither gas, nor solid, nor liquid, as ordinarily known, and he supposed it must be possible for matter to exist in a fourth state. We have gone far since Sir William's first experiments. The X-ray tube and radium have widely increased our knowledge of phenomena parallel to those of the Crookes tube. But I think we may still be glad to use Sir William's definition.

There is another very striking characteristic of the newer kinetic theory which differentiates it sharply from the older. The experiences of any one of the radiant particles in an atom which it crosses are quite unaffected by any chemical combination of that atom with others; that is to say, by any molecular associations it may have. Naturally, this simplifies investigation. We may, no doubt, ascribe this state of things to the fact that a radiant particle is concerned rather with the interior of the atom than with the exterior, and that it is the latter which is of importance in chemical action.

Let us take notice of one more important difference. The molecules of a gas move with velocities which vary at every collision, yet vary about a certain mean. But the peculiar motion of the radiant particle is only temporary. For only a very short time can any ray be described as matter in a fourth state; at the end of it the extraordinary condition has terminated, the particle has lost its tremendous speed or suffered some other change, and the ray ceases to exist. Speaking technically, we are dealing with initial, not permanent, conditions.

Let us now come back to resemblances between the two kinds of motion, for there is one point of similarity which is not quite so obvious as others I have mentioned, and is, I think, of the greatest importance; in fact, it is largely on account of this similarity that I have ventured to put the two theories together for comparison.

When the first experimenters in radioactivity allowed their streams of rays to fall upon materials of various kinds, they found that the irradiated surfaces were the sources of fresh streams of radiation. The secondary rays were sometimes of the same nature and quality as the primary, sometimes not. Further, they found that the secondaries, on striking material substances, could produce tertiaries, and so on. The examination of all the variations of this problem—the investigation of the consequences of changing the primary, of changing the substance, and last, but not least, of changing the form of the experimental arrangements—has been the cause of an enormous amount of work. There is a large literature dealing with secondary radiations of all kinds which, I imagine, but few have read with any completeness, and the subject has become, on the surface at least, complicated and difficult. Now I believe that it is possible to clear away the greater portion of this complexity at a stroke by the adoption of an idea which makes it possible to describe and discuss the whole of these phenomena in a very simple way. When an encounter takes place between two gas molecules, we suppose that the sum of the energies of the two is the same after the collision as before, and, further, that there are just two things to consider—two molecules—after as well as before. I think that we may carry this idea over almost bodily to the newer theory. A radiant particle encounters an atom. The particle is a definite thing; it contains a definite amount of energy, and whether it is an α, or β, or γ, or X-ray, its energy is to be found almost entirely inside a very minute volume. The encounter takes place. When it is over there are still two things, an atom and a radiant particle, going away from it. The sum of the energies of the two is still the same, which means that we deny a possibility much considered at one time, viz., that in the encounter the atom could be made radioactive, and could unlock a store of energy usually unavailable. We suppose that there is no energy to be considered except the original energy of the radiant particle, and we suppose that there are not now two or more radiant particles in place of the original one, which also is a limitation on previous ideas. It is a theory which ascribes a compuscular form to all the radiations. Each particle, α, β, γ, or X, is to be followed from its origin to its disappearance, and we have nothing to think of but the one particle threading its way through the atoms. It loses energy as it goes, though little at any one collision, and it passes out of our reckoning when it has lost it all. There are no secondary radiations other than radiant particles moving in directions which are different from those in which they moved at first. Even when a kathode ray excites an X-ray in the ordinary Röntgen tube, or the X-ray excites a kathode ray in a manner almost as well known, it is hardly an exception to this rule. The kathode ray has an encounter with an atom and disappears; simultaneously the X-ray comes out of the atom, a circumscribed corpuscle carrying on the energy of the kathode ray. There is a change, but it extends only to the external characteristics of the carrier of energy. The X-ray passes through the glass wall of the X-ray bulb, or at least it does so sometimes; it may pass through other matter as well, but sooner or later it has a fatal encounter with an atom, and the reverse change takes place. In all cases, in that of the undeviating α ray, or the β ray which suffers so many deflections, or the γ or X-rays, it is a matter of tracing the movements of individual minute quantities of energy until they finally melt away.

Let us consider one or two simple experimental results from this point of view in order that we may illustrate this corpuscular theory, and at the same time may learn something of the properties of the corpuscles and of the arrangements of the atoms through which they pass.

We take first one of the simpler cases, the movement of an α particle through a gas. The relatively large mass of the particle gives it an effectiveness which the other radiations do not possess. It moves straight through every atom it meets, and ionizes most of them. Very rarely does it suffer any deflection from its course until its velocity is nearly run down. Then, indeed, it does appear to depart considerably from the straight path, and it may be that it is much knocked about by collisions before it finally comes to comparative rest. In this way we may explain the distribution of the ionization along its path, which increases slowly at first and rapidly afterwards, until the α particle has nearly finished its journey; it then falls off rapidly. Considering that the ionization increases as the particle slows down and spends more time in each atom, and considering the more broken nature of the path near its end, the reason of these peculiarities is clear enough. Apart from its comparative simplicity, there are some other very interesting features of the particle's motion. It is found, for example, that the loss of energy which the particle incurs in crossing an atom is proportional to the square root of the atomic weight very nearly, and there is no certain explanation as yet of this curious law. And again, Geiger has examined the small scattering that does occur, and found that α particles when moving quickly may be swung round completely even by the thinnest films of gold leaf, though the number is so small that the effect would have remained undetected had it not been for the scintillation method which he and Rutherford have perfected. He has found that about one particle in 8,000 is returned in this way from a gold plate, which need consist only

[*] Discourse delivered at the Royal Institution by Prof. William H. Bragg, F.R.S.

of a few thicknesses of gold leaf in order to give the maximum effect.

Now let us taken an example from the behavior of the β rays. The β particle is so light that it is easily deflected, even though it moves several times as fast as the heavier α particle. Because it therefore possesses little energy its effects are much smaller, and no one has yet succeeded in handling a single β particle in the same way as Rutherford and Gieger have handled the other. We are obliged to content ourselves with observations of the effects of a crowd of β particles, since the combined action of many is necessary to give us an observable result; and at the same time that the β particle gives much less effect than the α, it has a much more irregular course, so that the problem is doubly difficult. We are, in fact, only just beginning to understand it. There is a compensation in the fact that its very liability to deflection makes it all the more interesting an object. It is possible—and this is the particular β-ray problem I wish to consider now—to examine the deflection of a single β particle by a single atom; the parallel result in the kinetic theory of gases has never, of course, been achieved.

Suppose that we project a stream of β rays against a thin plate and measure the relative number sent back, which we do by measuring the ionizations caused by the incident and returned rays respectively. We do this for varying thicknesses of the plate, and plot the results, as, for example, Madsen has done. His plate was made of gold leaves, which could be had of extreme fineness. From the relation thus obtained, it is possible to obtain with confidence the amount of β radiation that would be returned by the thinnest plate that could be imagined, only one molecule thick. In such case the particles turned back could have had but one collision, and we have achieved our purpose. Madsen's figures show that a plate weighing four milligrams to the square centimeter turned back a tenth of the β particles that fell upon it, and, so far as can be judged, the ratio of the proportion turned back to the weight of the plate would be almost doubled for very thin plates. We could go more into detail, and find the distribution of those that are returned; we should then have data from which we might determine in some measure the distribution of the centers of force inside the atom. We cannot follow this up now, but I would like to direct your attention to a curious indication which we obtain when we compare the results for gold with those which Madsen found for aluminium. They show that the lighter metal turns back fewer β particles, and that its power of absorbing a stream of rays is rather an absolute abstraction of energy. There is clearly an actual absorption effect, which is to be distinguished from the scattering effect. Indeed, the two effects are obviously of different importance in the two cases When a β ray strikes a gold atom it must be much more liable to deflection than when it strikes the lighter atom of aluminium. On the other hand, I think it can be shown clearly that in plowing through aluminum atoms there is a relatively quicker absorption of energy. We may illustrate this by a rough model. Let us stand an electro-magnet upright on the table, and let us suspend another magnet so that it can swing over the fixed one and just clear it. If we draw back the swinging magnet and let it go toward the fixed one, the currents running so that the two repel, then as the moving magnet tries to go by there will be a deflection depending on the relative speed, the closeness of approach, and the strength of the poles. This may represent the turning aside of an electron by a center of force inside an atom. Now let the magnet at the table be supported by a spiral spring so as to be still upright, but have some freedom of motion; then, when the experiment is repeated, the swinging magnet pushes the other more or less to one side; it is less deflected, but it has to give up some of its energy. This is exactly what happens in the case of the β particle. The center of force in the gold atom behaves like the stiffer electro-magnet on the table; it deflects the electron more, but robs it of less energy in doing so. It will not do to suppose the gold atom to differ from the aluminium atom simply in the number of centers of force, such as electrons, which it contains if it is supposed that they all act independently. There is some other fundamental difference, equivalent to a difference in the stiffness with which the electrons are set in their places. There are two things to be expressed in the behavior of the atom toward the β particle, as has been pointed out several times. H. W. Schmidt has actually calculated them from experiments which gave them indirectly and somewhat approximately. The method I have just outlined gives one of them directly, viz., that which is called the scattering coefficient, and I think the other can also be found directly by a method which will serve as an illustration of the behavior of γ rays.

We must first, however, consider the part which and X-ray play generally in this theory. Workers are by no means agreed as to the proper way in which to regard them, but there is no need to enter at once on a discussion as to their nature. It is well known that they have the most extraordinary powers of penetration, and are unaffected by electric or magnetic fields. They have one property which alone, as I think, brings them within our experience; that is to say, the power of exciting β rays from the atoms over which they pass. Were it not for this they would still be unknown. When we examine this production of β rays, we find that in the first place their speed depends on the quality of the γ rays which cause them, and not on the nature of the atoms in which they arise; in the second, that the β rays to a large degree continue the line of motion of the γ rays, as if the latter pushed them out of the atoms; and, lastly, that the number of the β rays depends on the intensity of the γ rays. It is these facts which suggest the simple theory I have already described. The γ ray is some minute thing which moves along in a straight line without change of form or nature, which penetrates atoms with far greater ease than the α or β particle, which is not electrified, and which sooner or later disappears inside an atom, handing on a large share of its energy to a β particle which takes its place. The absorption of γ rays is simply the measure of their disappearance in giving rise to β rays, one γ ray producing one β ray, and no more.

We find the same sort of scattering in the case of γ rays as in that of β rays. Of a stream of rays directed against a plate which it can penetrate easily, we find that a few are turned completely back, a very much larger number are only slightly turned out of their path, and the rest go on. The scattered rays are very similar to the original rays; there is no need to suppose that the original ray disappears, to be replaced by a secondary, any more than there is to suppose that α and β rays disappear and are replaced by others in similar cases. When, therefore, a γ ray enters an atom, three possibilities await it. The first is a negative one; it may go through the atom untouched, and this must happen in the majority of cases; the second chance is that of deflection, and the third that of conversion into a β ray, using the word conversion in a general sense, without going into details as to the nature of the process.

Now we may consider our γ-ray problem. Suppose a stream of these rays passing over a block of any substance, such as aluminium, or zinc, or lead. When they are really penetrating rays they are equally absorbed by equal weights of these materials, which means that in equal weights equal numbers of β rays spring into existence. If these β rays were able to move through equal weights of the metals, we should find in each metal the same "density" of β rays; and the important point is that this is independent of whether the rays are straight or crooked in their paths. If ten lines of given length were begun in every square centimeter of a sheet of paper, the ink used in drawing them would be independent of the straightness of the lines, but proportional to their length. Now if we make a cavity in each metal the β rays will cross it in their movements to and fro, and if a little air is introduced into the cavity, the ionization produced in it will be a measure of the density of the β rays, and therefore the average distance each moves in the metal. Experiment shows that we get twice as much ionization in a cavity in the lead as in a similar cavity in the aluminium, and we conclude that the β particle really has a longer track in the heavier metal. This experiment gives us the second constant of β-ray absorption, that is to say, the rate at which its energy is taken away from it; the other experiment gave the chance of deflection only. We see that the path of a β ray in aluminium is more direct, but of less length, than in lead; in the latter metal it has really a longer path, but it does not get so far away from its starting point because it suffers so many more deflections.

Finally, let us take a problem from the X-rays. Let us see how we may test the idea that X and γ rays do not ionize themselves, but leave all the work to be done by the β rays which they produce. Suppose a pencil of X-ray to pass across a vessel and to produce ionization therein. It is convenient to use, not the original X-rays, which are heterogeneous, but the rays which are scattered by a plate of tin on which the primary rays fall. Such "tin rays," as we often call them briefly, are fairly homogeneous, and give kathode rays of convenient penetration. In some experiments of mine the rays crossed a layer of oxygen 3.45 centimeters wide, having a density 0.00137, and the ionization produced was 227 on an arbitrary scale. The result may be put in the following way. Suppose, provisionally, that all this ionization is done indirectly; the oxygen has concerted so much X-ray energy into kathode-ray energy, and these kathode rays penetrating their one or two millimeters of oxygen, which is all they can do, have ionized the gas. Then we may say that, in crossing a layer of oxygen weighing 3.45×0.00137, or 0.00473 grain per square centimeter, enough kathode rays have been produced to cause an ionization of 227 units, and therefore that a layer weighing one milligram per square centimeter would produce 48 units in the same way. We now proceed to compare this production in oxygen with the similar effect in a metal such as silver. Stretching a silver foil across the chamber in the path of the rays, we find that under the same intensity of rays the ionization is largely increased, and the change is due to kathode rays which the X-rays have generated in the silver. Not all these rays get out of the silver, but we can overcome this difficulty by taking silver foils of different thickness, drawing a curve connecting the effect of the foils with their thickness, taking the curve back to the origin, and so finding what would be the effect of a foil so thin that all the kathode rays did get out. In my case I found that a milligram of silver produced enough kathode rays to give an ionization 1,580. This is thirty-three times as much as the oxygen could do. Now, according to our theory, this should be because silver absorbs tin rays thirty-three times more than oxygen does, and experiment showed this to be very nearly the case. In finding the absorbing power of oxygen, I measured first those of carbon and oxalic acid, and then proceeded by calculation, for the absorption in a gas is difficult to determine.

Two interesting points appeared in this experiment. In the first place, the ratio between the two quantities of kathode rays, which appear on the two sides of a silver leaf through which the "tin rays" pass, is nearly constant for different thicknesses of leaf. With the thinnest leaf obtainable each quantity was about half its full value. It would have been desirable to have had still thinner leaves; but it is fairly clear that the ratio would be nearly the same for extreme thinness. The kathode radiation, which appears on the side of the leaf whence the X-rays emerge, is 1.30 times that which appears on the other, and we may take it that this would be the case even if the leaf were but one atom thick. Thus when an X-ray plunges into an atom in which its energy is converted into that of a kathode ray, the kathode ray may emerge at any point, but there is a 30 per cent greater chance that it will more or less continue the line of motion of the X-ray than that it will not. In previous work on the conversion of γ-ray into β-ray energy, I have found that the β ray may practically be supposed to continue the line of motion of the γ ray, so that there is a great difference in behavior of the two classes of ray in this respect. It is remarkable that the scattering of the γ rays shows also a much greater dissymmetry than is found in the case of X-rays. It looks as if the β rays that appear when γ or X-rays impinge on atoms are related rather to the scattered than to the unscattered primary rays. Putting it somewhat crudely, no doubt, it might be said that when a γ or X-ray is deflected in passing through an atom, it runs a risk of being converted into a β ray in the process, so that β rays are found disturbed about the atom in rough proportions to the secondary γ or X-rays. In the case of γ rays this practically amounts to their all going straight on at first; in the case of X-rays the distribution is more uniform.

Another interesting point arises in this way. When the X-rays from tin are allowed to pass into the ionization chamber through increasing thicknesses of silver foil, the kathode rays grow at a rate which is not represented by the exponential curve usually assumed. The amount is for some time more nearly proportional to the thickness of the foil. A second foil adds its own effect without destroying much of the one on which it is laid. This may easily be ascribed to the relation of the ionization due to the β particle to the energy it has to spend. The ionization is nearly all at the end of the path, and the second layer does not absorb the rays made in the first because they are still at the beginning of their career.

These few experiments which I have described may serve to illustrate both the justice and the convenience of placing all these rays, α, β, γ, and X, in one class. We are tempted to consider them all as corpuscular radiations of some sort, and we then look upon our reasearches into their behavior as attempts to understand the collisions of the various new corpuscles with the constituent centers of force in the atoms. But if we ascribe corpuscular properties to the γ and X-rays, we are led far away from the original speculations as to their nature. Stokes supposed them to be spreading æther pulses, but in his theory the energy of the pulse spreads on ever-widening surfaces as the time passes, and is utterly insufficient to provide the energy of the β rays which the γ or X-rays excite. Some sort of mechanism has to be devised by which the energy of the γ ray moves on without spreading, so that at the fateful moment it may be all handed over to the β ray, which carries it on. I had the hardihood myself to propose a theory of this kind. My idea was that the γ or X-ray might be considered as an electron which had assumed a cloak of

darkness in the form of sufficient positive electricity to neutralize its charge. Nor do I see any reason for abandoning this idea, for it is at least a good working hypothesis. It means, of course, that not only does the energy of the β ray come from the γ ray, but the β ray itself.

Many insist that my neutral corpuscle is too material, and that something more ethereal is wanted, for it appears that ultra-violet light possesses many of the properties of X and γ rays. It can excite electrons to motion, and sometimes the speed of the electron depends on the quality of the light, and not on the nature of the material from which it springs. They propose, therefore, a quasi-corpuscular theory of light, γ and X-rays being included. The immediate objection to this proposal is that it seems to throw away at once all the marvelous explanation of interference and diffraction which Young and Fresnel founded on a theory of spreading waves, and I do not think anyone has yet made good this defect. The light corpuscle which is proposed is a perfectly new postulate. It is to move with the velocity of light, keeping a circumscribed and invariable form, to have energy and momentum, and to be capable of replacing and being replaced by an electron which possesses the same energy but moves at a slower rate, and, of course, it has to do all that the old light waves did. The whole situation is most remarkable and puzzling. We are working and waiting for some solution which, perhaps, will come in a moment unexpectedly. Meanwhile, we must just try to verify and extend our facts, and be content to piece together parts of the puzzle, since we cannot, as yet, manage the whole. My object has been to show you how we may conveniently bind together a large number of the phenomena of radioactivity into an easily grasped bundle, using a kinetic theory which has many points of resemblance to the older kinetic theory of gases.

Surface Tension and Lead Poisoning

The surface of the mercury in a barometer is convex, but when a glass tube is partly filled with water, the surface of the liquid assumes a concave form. A glass tube or rod which has been immersed in water remains wet after it is withdrawn, because a film of water adheres to the glass, but mercury does not adhere to glass, or wet it. Every liquid assumes a concave surface when in contact with a solid which it wets, and a convex surface in contact with a solid which it does not wet. Water does not wet grease, and therefore it assumes a convex surface in a greased glass tube and the form of convex drops when sprinkled on a greased glass plate. The leaves of plants are covered with a film of wax, and for this reason are not easily wetted. Dew stands in drops on leaves, without wetting the surface, and the funnel-shaped leaves of some plants collect rain in the form of a large flattened drop, which does not wet the leaf. In the absence of wax or grease, water readily wets vegetable tissue, for which it possesses a strong affinity. When leaves are exposed to long-continued rain, their thin coating of wax is gradually washed away, and they then become soaked with water.

The feathers of ducks and other aquatic birds shed water, and do not become wet, because they are saturated with oil. This oil is not washed away as the wax is washed from leaves by long-continued rain, because the feathers possess a stronger affinity for oil than for water.

What has all this to do with poisoning? Prof. O. N. Witt gives the answer in a long and very entertaining article in *Prometheus*, from which only the essential facts are here cited.

White lead, like the feathers of birds, is more easily wetted by oil than by water, and, when once saturated with oil, is permanently protected from the action of water and aqueous solvents. Hence, though white lead is very poisonous, it can be safely used as an oil paint, even in kitchens. House painters and artists have long since ceased to use dry-ground white lead, which is both troublesome and dangerous to work with, and buy white lead ground in oil. In this way the danger of lead poisoning is removed from the painter's shop, but not from the white lead factory, where the white lead is first dried in heated rooms, then finely ground, and finally ground again with oil. Although every precaution is taken in these operations, it is impossible to prevent some of the poisonous white lead being scattered as fine dust in the air which the workmen breathe.

One day a genius, whose name is lost to fame, reflected that as white lead is produced in the wet way, as a chemical precipitate, it is already as finely divided as possible, and that there would be no necessity for grinding it if it were not agglomerated by drying. But is it necessary to dry a substance which possesses so much greater affinity for oil than for water? Experiment proves that when the wet precipitate of white lead is ground with linseed oil, the water is expelled and rises to the top of the mass as a clear liquid, which can be poured off. The few drops of water which adhere to the pigment are carefully wiped off. This new process almost entirely eliminates the danger of lead poisoning by white lead dust scattered in the air of the factory.

Magnalium Equalizers

An apparatus whose function is to acquire the potential prevalent at the point at which it is placed, thus rendering it accessible to measurement, is termed an equalizer. To illustrate its use by an example, we may suppose that the upper of two metal plates *A* and *B*, shown in Fig. 1, to be charged from a storage battery, so that an electrostatic field is established, whose direction is indicated by the three arrows, representing lines of force, between the two plates. An equalizer *P*, connected to an electrometer, then indicates the potential at the point occupied by the equalizer.

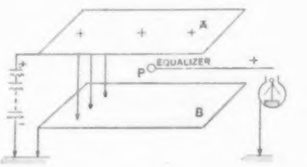


Fig. 1

Different types of equalizers have been employed. Among these may be mentioned the familiar points or combs, diagrammatically represented at *a* in Fig. 2. The form shown in Fig. 2, *b*, depends for its action upon the discharging properties of a stream of water droplets, while *c* indicates a similar use of a flame, and *d* is intended to denote diagrammatically the use of radioactive substances, connected to the electrometer to effect equalization.

The mode of action of this last type of device may be briefly outlined as follows: The radioactive preparation, consisting as a rule of a sheet of platinum coated with polonium, strongly ionizes the air in its immediate proximity, thereby rendering the same conducting. So long as there exists any difference in potential between the equalizer and its surroundings, the ions bearing the corresponding charge fly to meet the plate and charge it up to the proper potential.

All these forms of equalizers possess certain disadvantages which render them ill adapted for the investigation of the electrical conditions of the atmosphere. In the case of balloon ascents, the flame type of equalizer is out of the question. The water drop equalizer requires frequent attention, and polonium is a costly material. It is therefore gratifying to hear that another type of instrument has recently been introduced, which depends on a certain action of light, and which is in many respects superior to the older forms. It has been known for some time that plates of zinc or aluminium, with a freshly exposed bright surface, exert an equalizing influence under the action of light. This effect, however, dies down very quickly. Recently however it has been shown by Dember that the alloy of magnesium and aluminium, known as magnalium, is peculiarly well adapted for use as an equalizer. Freshly scraped magnalium retains its equalizing property for several hours, and when it has lost its activity, it can very quickly be restored by simply polishing its surface.

It seems then that we have now a thoroughly satisfactory agent at our disposal, and one which is not dependent upon narrowly prescribed laboratory conditions, but which will readily adapt itself to the exigencies of circumstances.—Excerpt from *Prometheus*.

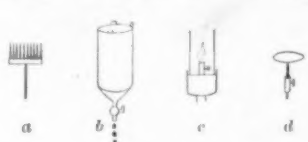


Fig. 2.

The Great Red Spot of Jupiter

Jupiter, the giant of our family of planets, is now in a very favorable position for observation. It was in opposition to the sun on May 1st, will be visible all night during the entire month of May, and will be evening star until September.

This great planet, which possesses 1,300 times the bulk and 310 times the mass of the earth, accomplishes its rotation on its axis in 9 hours and 50 minutes. As the equatorial circumference is 275,000 miles, the linear rotational velocity of a point on the equator is nearly 8 miles per second. In consequence of this enormous velocity or rotation the planet is greatly flattened at the poles.

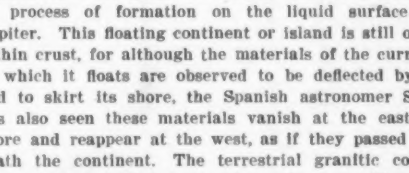
The telescope shows a series of bands or belts crossing the planet's disk parallel to the equator and continually changing in width, form, color and general appearance. They are sometimes called belts of clouds, but they more probably represent currents in the mass of the planet, somewhat analogous to the terrestrial Gulf Stream. The whole globe of Jupiter is composed of parallel circular currents, moving with different velocities, the equatorial current being the swiftest. A similar phenomenon is observed in the sun, which does not rotate as a rigid mass, but moves most rapidly at the equator. The velocity is not even constant for the same current. Spots near the equator of Jupiter, which accomplished a complete rotation in 9 hours, 50 minutes and 6 seconds in 1880, occupied 9 hours, 50 minutes and 34 seconds in performing the rotation in 1895. In short, Jupiter is a planet which is not yet solidified.

A very remarkable detail of the surface of Jupiter, which is sometimes very conspicuous and at other times is barely perceptible (probably owing to clouds in the planet's atmosphere), is a large oval spot of ruddy hue, situated in the southern equatorial belt, between 25 and 30 degrees of south latitude. This spot is 26,000 miles long and 9,300 miles wide, and it covers as large a proportion of the planet's surface as Australia covers of the surface of the earth. The red spot moves a little less swiftly than the equatorial current and with a slightly varying velocity, accomplishing its revolution about the planet in 9 hours, 55 minutes and 35 seconds in 1880, and in 9 hours, 55 minutes and 42 seconds in 1900.

In a contribution to the April number of *L'Astronomie*, quoted in *Cosmos*, Antoniadi expresses the opinion that this great red spot is the first continent in process of formation on the liquid surface of Jupiter. This floating continent or island is still only a thin crust, for although the materials of the current in which it floats are observed to be deflected by it and to skirt its shore, the Spanish astronomer Sola has also seen these materials vanish at the eastern shore and reappear at the west, as if they passed beneath the continent. The terrestrial granitic continents, in their initial stage of formation, were likewise thin crusts floating on the surface of the hot and liquid globe.

A Wrench for Wing Nuts

Most of us have had to tighten up wing nuts by hand, which, of course, is what they are intended for, but sometimes it is convenient to be able to apply some



A WRENCH FOR WING NUTS

tool for the tightening up of these nuts. For such a purpose the simple little tool illustrated in the accompanying line engraving, taken from the *Horseless Age*, will be found convenient. The wrench is made of flat stock about 3/16 inch thick. The handle *A* is made in various sizes, according to the size of the wing nut, five times the distance across the wings of the nut being the usual practice. Two slots *B* are cut at right angles to each other in the circular part of the wrench, as shown. At their intersection the central opening is enlarged, so as to permit the screw on which the wing nut turns to enter.—*Machinery*.

Black English Stone Pulp.—Heat pumice stone to redness, quench it with water, crush it to a fine powder and sift through a hair sieve. Put the powder into a suitable vessel and add enough varnish to make a thick paste. Add lamp black, then more varnish and rub it down until the fluid is uniform. With this mass, well beaten cardboard or double paper is coated, dried, coated a second time, then dried and pressed.

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